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Vilnius urban sustainability assessment with an emphasis on pollution

Edmundas Zavadskas[1],

Artūras Kaklauskas[2],

Jonas Šaparauskas[1],

Darius Kalibatas[1]

[1] Department of Construction Technology and Management

[2] Department of Construction Economics and Property Management, Vilnius Gediminas Technical University, Saulėtekio al. 11, LT-10223 Vilnius, Lithuania
E-mail: Edmundas.Zavadskas@adm.vtu.lt

Successful strategies for sustainable urban development should be more or less compatible with political, economic, social, cultural, institutional, technological, environmental, legal / regulatory and educational situations in the country. The list of urban sustainability indicators is not finite. Each year hundreds of social, economic and environmental indicators are being established in the world. Therefore, decision-making methods should be used in order to evaluate successful strategies for sustainable urban development. The above questions have been analysed in the paper. In order to shed more light on the analysis of Vilnius urban sustainability with an emphasis on pollution, particular recommendations for environmental factors such as transport and pollution, noise, indoor microclimate and allergens, their impact on real estate price, market value and mass appraisal value are presented.

Key words: sustainable urban development, pollution, decision making, case studies

INTRODUCTION

Air pollutant emissions from stationary sources in Vilnius are the greatest among the other cities in the country. Emissions from energy producing objects have decreased due to the smaller amount of thermal energy produced and the lower use of fuel with a high sulphur concentration. In total, the share of emissions from transport has been increasing. Transport emits about 88% of all pollutant emissions in Vilnius. Industry, energy and transport are the main soil pollutants in Vilnius, and lead is accumulating on the roadsides of busy streets. In territories with industrial enterprises, excessive amounts of heavy metals and oil products can be detected. They are hazardous to the environment and human health, especially when chemical substances from the soil get into the ground and surface water. Old cars and heavy transport flows, densely built areas and the poor window acoustic isolation contribute to unacceptable noise levels in residential areas. Therefore, noise levels exceed the norms in most residential zones.

Evaluation and analysis of Vilnius urban sustainability with an emphasis on pollution are necessary in order to minimize the above problems.

Sustainability assessment consists of several seemingly simple procedures: 1) selection of a set of indicators, 2) identifying their values, and 3) complex evaluation of indicators. However, further analysis shows that each of these stages is rather complicated and has many different constraints.

The list of urban sustainability indicators is not finite. Each year hundreds of social, economic and environmental indicators are being established in the world. From this great number, tens of indicators are recognized as applicable for everyday use. Besides, there are no recommendations what number of indicators should describe a city: ten or hundred? It is also not clear whether the set of indicators should consist of simple, integrated or a combination of simple and integrated indicators.

Selecting an "ideal" set of indicators does not ensure the right result. Why? Very often it is not possible to define the values of the desirable indicators.

The so-called index of sustainability could be calculated by a wide range of methods varying from simple to very sophisticated methodologies. The results obtained may differ depending on the method applied.

The aims of the present work were to analyse the mentioned problems on the theoretical level and to suggest ways of their possible solution, as well as to try to assess the level of sustainability of a particular city.

SELECTION OF INDICATORS

The requirements for developing a comprehensive system of indicators are as follows: the system must be able to reflect every aspect of urban development, data for the indices must be possible to be collected from reliable sources and be consistent, the index system should accomodate the relationship between the evaluation indices and the evaluation criteria, especially to generate the corresponding evaluation indices based on evaluators' criteria (Feng, Xu, 1999).

According to Spangenberg et al. (2002), the indicators should be primarily national in scale and scope, relevant to the main objective of assessing progress towards sustainability, understandable, i.e. clear, simple and unambiguous, realisable within the capacities of national governments, given logistics, time, technical and other constraints, conceptually well founded, limited in number, remaining open-ended and adaptable to future developments, broad in coverage of Agenda 21 and all aspects of sustainable development, representative of an international consensus to the extent possible, and dependent on the data that are readily available or available at a reasonable cost-to-benefit ratio, adequately documented, of known quality and updated at regular intervals.

The Lithuanian researcher M. Burinskienė (2000, 2004) recomends to choose measurable indicators, i. e. embodied by numbers, percentage or coefficients, indicators whose data are published officially, i. e. the data collection methodology and the definitions used are clear.

It is important to point out that much effort has been made to establish the set of indicators representing urban sustainability in the best way. Despite all efforts, one may obtain different indicator systems. Indicator sets may contain many specific indicators, a few composite indicators, and a combination of key and simple indicators (Tweed, Jones, 2000).

It is possible to distinguish core and interlinkage indicators. One-dimensional core indicators are economic, environmental and institutional. Interlinkage indicators are environmental-economic, socio-economic, socio-environmental, economic-institutional, socio-institutional and environmental-institutional (Spangenberg, 2002).

Šaparauskas (2003, 2004) suggests grouping the indicators of urban sustainability into four groups. The third group of social, economic and environmental indicators represents the classical approach to sustainable development. Their interpretation and value for urban sustainability have been discussed in detail. The fourth group of engineering-technical indices characterises the "technical" side of a sustainable city: engineering infrastructure (quality, efficiency, development degree, etc.), constructions and buildings of different purposes (wellness, economy, influence on the environment, aesthetics, etc.), of physical territorial planning.

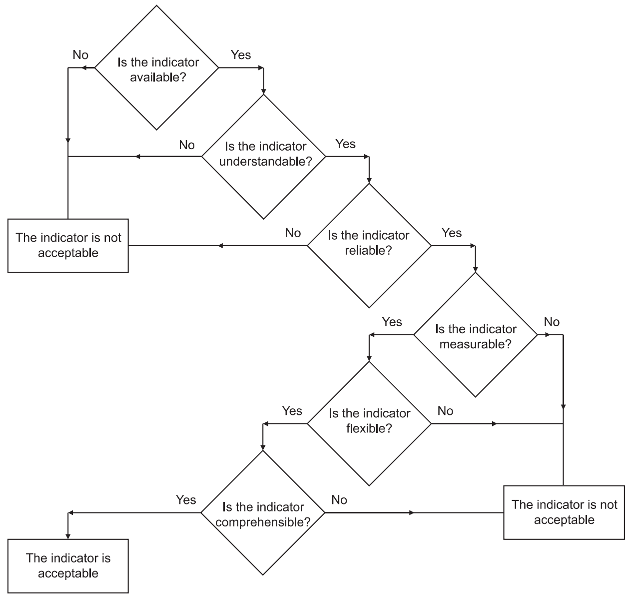


Fig. 1. Procedures of indicator selection

The authors suggest six procedures for selection of most applicable indicators (see Fig. 1).

Based on the studies, on the framework for indicator selection (see Fig. 1) and available data, the authors have composed a system of indicators for sustainability evaluation of the Vilnius city (Table 1).

APPLYING TWO EVALUATION METHODS

Traffic light approach

Measurement indicators of sustainability by traffic (signal) lights or flags (see Fig. 1) over time can help explain weather a city's sustainability is getting better or worse. Indicators are

Table 1. **Indicator system for sustainability evaluation of the Vilnius city (m = 12, n = 2)**

Indicators	Units	Years compared	
		2003	2004
Economical			
1. Unemployment rate	% per year	5.5	3.6
2. Direct foreign investment per inhabitant	thou. Lt	14.999	14.304
3. Material investment per inhabitant	Lt	5206	6310
4. Annual turnover of construction enterprises	mill. Lt	1403	1542
Social			
5. Average earnings per job	Lt	1310	1391
6. Municipal expenses for social needs	thou. Lt	378.810	459.390
7. Floor area per person in housing	m^2	22.6	23.3
8. Number of people identifying obstacles to obtaining health care	per 100 000 inhabitants	1871.6	2023.5
Environmental			
9. CO_2 emissions from stationary sources	t/year	900	1030
10. Municipal expenses for water quality treatment and measurement	thou. Lt	307.562	373.722
11. Total solid waste produced	thou. t	235.734	242.055
12. Green areas per inhabitant	m^2	8.0	9.1

being measured for years and the index below can summarise trends since a baseline set. If each indicator starts with a score of 2, progress or deterioration can be tracked against this baseline. The sum of the score starts with a baseline. The higher the score, the more sustainable the city is (Nijkamp, Vreeker, 2000).

Twelve of the indicators have been measured for two years. The sum of the score started with a baseline of 24 in 2003, while the sum of the score in year 2004 was 28.

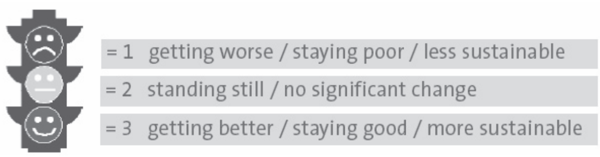


Fig. 2. Traffic lights

Simple additive weighting when weights are defined by the entropy method

The simple additive weighting method (SAW) is probably the best known and very widely used. The model is used to aggregate the scores into one score based on the criteria weights (Hwang, Yoon, 1981; Balcomb, Curtner, 2000; Triantaphyllou, 2000; Dejus, 2002; Zavadskas, Kaklauskas, 1996; Zavadskas et al., 2007).

At first, the scores are normalised (converted) by the formulas:

$$x_{ij} = \frac{a_{ij}}{a_j^{\max}} \quad (1)$$

$$x_{ij} = \frac{a_j^{\min}}{a_{ij}} \quad (2)$$

where a_{ij} is a score for the criterion. When the criteria are maximised, formula 1 should be used, and formula 2 should be used when the criteria are minimised.

Then, the scores are aggregated into one score:

$$S_{SAW} = \max_j \sum_{i=1}^{m} x_{ij} \times w_i , \;\; j = 1,\dots, n. \quad (3)$$

where S_{SAW} is the total score, n is the number of criteria, w_i is the weight of a criterion, and x_{ij} is the normalised score for a criterion.

A set of alternatives contains a certain amount of information, and entropy can be used as a tool in criteria evaluation (Shannon, Weaver, 1947). The idea of entropy is particularly useful for investigating contrasts among the sets of data. By using eq. (4) we obtain p_{ij} for all i and j:

$$p_{ij} = \frac{a_{ij}}{\sum_{j=1}^{n} a_{ij}}, \; i = 1,\dots,m \quad (4)$$

The entropy of each attribute, E_i, the degree of diversification, d_i, and the normalized weight, w_i, are calculated by using eqs. (5), (6), and (7), respectively. They are:

$$E_i = -k \sum_{j=1}^{n} p_{ij} \ln p_{ij} , \; i = 1,\dots,m, \quad (5)$$

where k represents the constant $k = \frac{1}{\ln n}$ which guarantees that $0 \le E_i \le 1$.

$$d_i = 1 - E_i , \; i = 1,\dots,m. \quad (6)$$

$$w_i = \frac{d_i}{\sum_{i=1}^{m} d_i}. \quad (7)$$

Calculations according to formulas (4–7) and (1–3) gave the following results: $S_{2003} = 0.758$; $S_{2004} = 0.992$.

In order to throw more light on the analysis of Vilnius urban sustainability with an emphasis on pollution (see Table 1), particular recommendations regarding environmental factors such as Vilnius transport and the analysis of the impact of pollution, noise, indoor microclimate and allergens causing allergy in premises, their impact on real estate price, market value and mass appraisal value are presented below.

RECOMMENDATIONS REGARDING VILNIUS TRANSPORT

An analysis and particular recommendations for Vilnius are presented on the example of transport.

Evidence suggests that allergic respiratory diseases such as hay fever and bronchial asthma have become more common worldwide in the last two decades, and reasons for this increase are still largely unknown. A major responsible factor could be outdoor air pollution as derived from cars and other vehicles. Studies have demonstrated that urbanization, high levels of vehicle emissions and the western lifestyle are correlated with the increasing frequency of pollen-induced respiratory allergies (D'Amato, 2001). Air pollution may also cause heart diseases. High levels of pollution caused by heavy traffic and factories may trigger and speed up the narrowing of arteries and have immense implications on public health. Automobiles also pollute water; e.g., runoff from highways and roads can seep into our water systems and soil, impacting agricultural production and the environment. Pollution is hazardous to our health and is especially harmful to children, the elderly and those with respiratory ailments.

Air pollution may cause health problems for people living away from a two-way traffic road at peak periods. For example, over a period of one year (1990), surface soil samples were collected on each side of a two-way traffic road at a distance of 10 m and 500 m. The open site under study showed wind and rain to be two important parameters in transport pollution. In peak periods, the level of lead was very high at a distance of 1.5 m from the road (643 $\mu g \cdot g^{-1}$). Nevertheless, the residual level 500 m from the road remained significant (146 $\mu \cdot g^{-1}$). When it rains, the lead pollution remains within close proximity and is also quite low because the lead penetrates deep into the soil by percolation; in dry conditions the pollution is carried by the wind to a distance of 500 m or more (Piron-Frenet et al., 1994).

The low technical parameters of some major Vilnius streets and crossroads restrict the traffic, and long distances between connections of these streets give rise to a greater transport concentration as well as traffic and pedestrian jams. The present network of Vilnius streets in the rush hours reaches road capacity limits; therefore, it is essential to reconstruct and develop streets, crossroads and bridges. If the network density is not increased, serious ecological consequences from heavy transportation may occur, because even at the moment in many places the environmental impact exceeds normative requirements. The high concentration of automobiles is one of the reasons for the increase in transport flow. Since public transportation (buses, trolleybuses, mini buses) is the main means of conveyance for most residents, a priority has been set on this area. Different actions need to be undertaken due to worsening ecological conditions and a shortage of parking places, as well as the insufficiently developed transportation infrastructure which causes huge traffic jams and is time-consuming both for drivers and passengers during rush hours (Vilnius, 2002).

Vehicles are the largest source of pollution in Vilnius. They pollute urban territories with exhaust gases, are very dynamic and have access to all urban territories, i.e. residential and industrial areas, urban centres, hospital and sanatorium areas and recreation zones. Therefore, the ecologic situation in Vilnius is constantly deteriorating. Exhaust gases contain about 200 various chemical compounds, and many of them are cancerigenic. The increasing pollution in urban areas has a negative effect on both the environment and traffic participants such as cyclists and pedestrians.

The average morbidity in unpolluted Vilnius areas is 125 per 100,000 people (age 0–19), and in polluted areas it reaches 216 per 100,000 people. There are by 72% more cases of chronic bronchitis among residents of polluted areas as compared to unpolluted areas. Another important regularity is an obvious correlation between atmospheric pollution and acute myocardial infarction morbidity.

Public passenger transport influences the preservation of the environmental balance. Atmospheric pollution data show that the emission of the main pollutants per public transport passenger is 4–8 times lower; besides, public transport consumes five times less energy per passenger than private transport. Public transport makes less noise and pollutes the environment less (per passenger).

The following activities are planned according to the Vilnius City Strategic Plan 2002–2011 in order to minimize the negative impact of the traffic on the environment (Vilnius…, 2002):

- to prepare city maps of noise and air pollution;
- to modernize existing systems of traffic management and to introduce new technologies;
- to increase the permeatability of the current network by introducing additional traffic lines, to optimize the working regime of traffic lights and to implement the "green wave" principle;
- to introduce technical and engineering protective measures (e.g., acoustic walls, greenery, causeys, noise muffling windows) to decrease the impact of transport;
- to approve and hold to the regulations of the program for the Vilnius City safe traffic, with exceptional attention to the safety of pedestrians and cyclists;
- to ensure standard street lighting during dark period hours;
- to improve the information system of the city communication;
- to promote the usage of ecological fuel, giving priority to electric means of transport.

Also, residents should be supplied with information on air and drinking water quality, on the ways to minimize health risks from the poor quality of air, and to reduce their contribution to pollution (Regional…, 1999).

Each of the general recommendations proposed at this stage carries several particular alternatives. For example, implementing the e-City (e-City…, 2003) project by one of the authors, a large number of worldwide public transport passenger and operator information systems have been analyzed. On the basis of the best practice analysis of the situation in this sphere in Vilnius, of available resources and experience, specific requirements for the establishment of such systems in Vilnius have been proposed. When the effects of the implementation of the project will be obvious, i.e. when the e-City and Passenger and Operator Information System will start functioning in Vilnius, the level of pollution in the city will decrease because:

- people will be supplied with information on the air quality, the ways of reducing health hazards, and how they can reduce atmospheric pollution caused by them. After the implementation of effective Passenger Information Systems, passengers of public transport and drivers of individual cars will be able to choose less polluted routes. In this way traffic jams in the most polluted city streets will be reduced;
- after implementation of an effective Operator Information System, the optimization of routes for various vehicles and the operation of their movement reliability will be more rational. With the help of these organizational means, the rational distribution of vehicles in the street network and coordination of all types of public transport, implementation of the park and ride system, pollution in the city will decrease. By using organizational means, e.g., rational distribution of transport flows in the network of streets, control of vehicles during technical inspections, forbidding heavy transport in some areas of the city at night, and coordinated traffic regulation systems, negative effects of transport on the environment may be reduced by 18–24 per cent;
- using the research of traffic flows performed by the Operator Information System and maps of pollution compiled as a result of the research, rational technological means (improvement of vehicles and fuel, use of electric transport) would help to reduce pollution;
- using the research of traffic flows performed by the Operator Information System and maps of pollution compiled as a result of the research, rational means for urban planning and construction (rational planning of the street network, i.e. bypasses, highways of incessant traffic, priority to the development of public transport, rational arrangement of buildings in urbanization areas, use of houses-displays, use of sound-proof windows) would reduce the pollution.

Implementation of e-Tickets and Operator and Passenger Information Systems developed within the project would also remarkably enhance the effectiveness of the regulation of transport flows. More precise data on public transport passenger flows obtained with the help of these systems, modeling of transport flows and various organizational and technological means, as well as means of urban construction and planning would provide for objective conditions to reduce the additional use of fuel at crossroads when engines are idle and to reduce pollution of the environment by exhaust gases due to acceleration and deceleration of transport, etc.

ANALYSIS OF THE IMPACT OF POLLUTION, NOISE, INDOOR MICROCLIMATE AND ALLERGENS CAUSING ALLERGY IN PREMISES ON REAL ESTATE PRICE, MARKET VALUE AND MASS APPRAISAL VALUE

This chapter is based on the research of the Lincoln Institute of Land Policy Fellowship "Development of Market-Based Land Mass Appraisal Online System for Land Taxation" (LMAS-LT).

The Antakalnis and Žirmūnai areas of Vilnius (the Lithuanian capital) alongside the river (see Fig. 3) have been chosen to analyse the impact of pollution, noise, indoor microclimate and allergens causing allergy in premises on the real estate price, market value and mass appraisal value. The area is bounded by the Antakalnio, Žirmūnų, Kareivių and Šilo streets. It has also been selected due to the fact that the apartment houses located in it were built approximately in the same period (1960–1970).

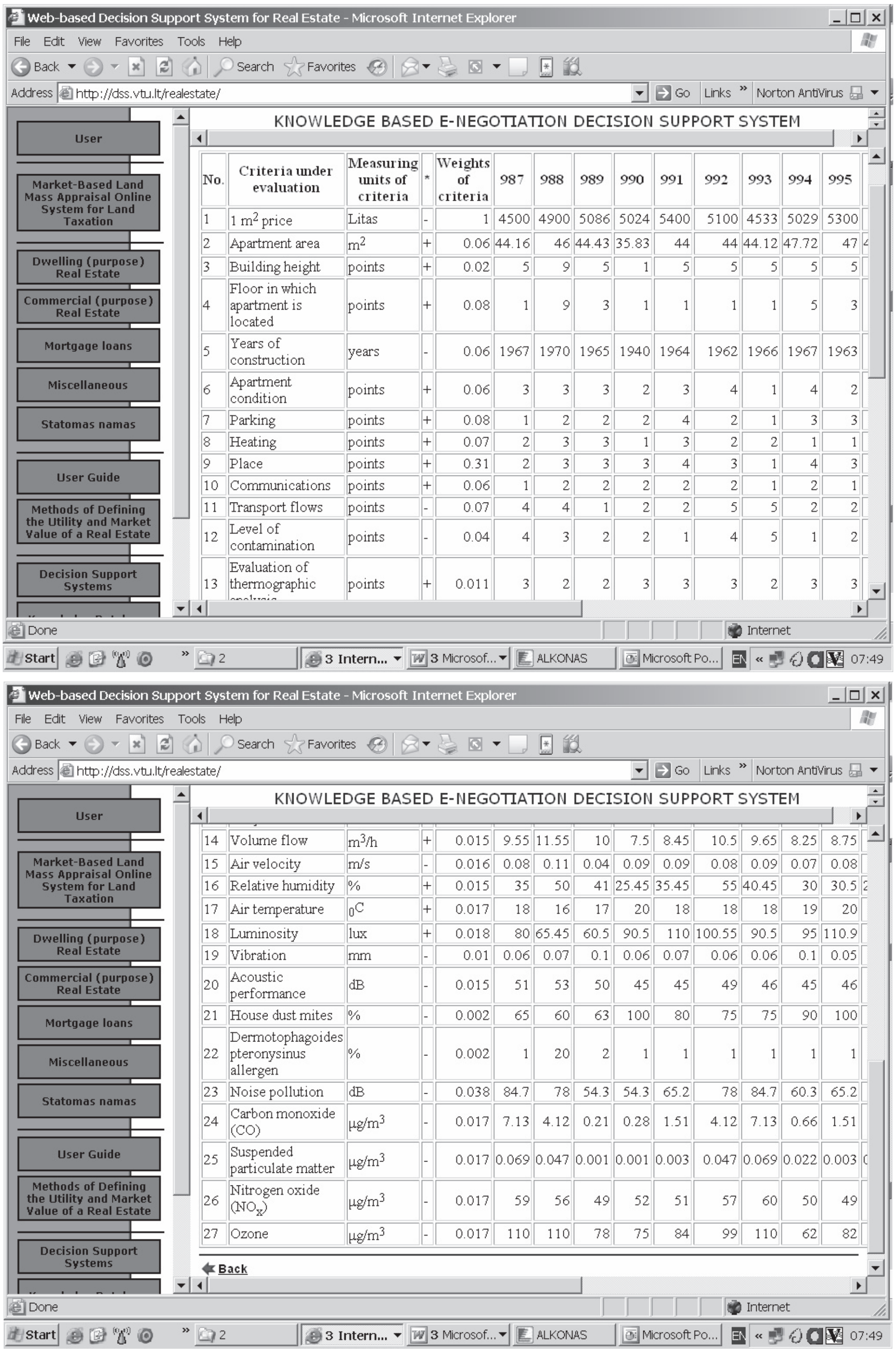
Figure 3D depicts the objects (2-room apartments) whose supply price, market value and mass appraisal value have been analysed. These 2-room apartments are almost evenly distributed alongside the Neris River banks. The valuation of 2-room apartments under consideration was performed with a more precise and accurate consideration by analysing not only traditional factors of the real estate value, but also other factors influencing on this value. The mass appraisal value is determined according to the LMAS-LT by using a system of criteria which consists of three subsystems: criteria that are usually employed for assessment of the market value of property by real estate companies; criteria describing the indoor microclimate and allergens of an apartment; criteria describing air and noise pollution of the environment. Also, the impact of the time factor on the transaction prices has been analysed, with the subsequent adjustment of prices.

Fig. 3. Location of real estate under consideration

Fig. 4. Sections where air pollution and noise level were investigated

The LMAS-LT includes an intelligent decision support tool based on methods of alternative generation, multiple criteria analysis and negotiation (Kaklauskas et al., 2005a,b, 2006 a, b, Zavadskas et al., 2002, 2003, 2004 a, b, c, 2005) developed by authors.

In Fig. 3 these 2-room apartments are enumerated according to the system used in multiple criteria analysis (see Fig. 5). In this case, our main target was to examine the impact of air pollution and noise on real estate price dynamics. When measuring air and noise pollution in several sections in Žirmūnai sections A–A, B–B and C–C; in Antakalnis sections D–D, E–E, also sepa-



KNOWLEDGE BASED E-NEGOTIATION DECISION SUPPORT SYSTEM

No.	Criteria under evaluation	Measuring units of criteria	*	Weights of criteria	987	988	989	990	991	992	993	994	995
1	1 m² price	Litas	-	1	4500	4900	5086	5024	5400	5100	4533	5029	5300
2	Apartment area	m²	+	0.06	44.16	46	44.43	35.83	44	44	44.12	47.72	47
3	Building height	points	+	0.02	5	9	5	1	5	5	5	5	5
4	Floor in which apartment is located	points	+	0.08	1	9	3	1	1	1	1	5	3
5	Years of construction	years	-	0.06	1967	1970	1965	1940	1964	1962	1966	1967	1963
6	Apartment condition	points	+	0.06	3	3	3	2	3	4	1	4	2
7	Parking	points	+	0.08	1	2	2	2	4	2	1	3	3
8	Heating	points	+	0.07	2	3	3	1	3	2	2	1	1
9	Place	points	+	0.31	2	3	3	3	4	3	1	4	3
10	Communications	points	+	0.06	1	2	2	2	2	2	1	2	1
11	Transport flows	points	-	0.07	4	4	1	2	2	5	5	2	2
12	Level of contamination	points	-	0.04	4	3	2	2	1	4	5	1	2
13	Evaluation of thermographic	points	+	0.011	3	2	2	3	3	3	2	3	3
14	Volume flow	m³/h	+	0.015	9.55	11.55	10	7.5	8.45	10.5	9.65	8.25	8.75
15	Air velocity	m/s	-	0.016	0.08	0.11	0.04	0.09	0.09	0.08	0.09	0.07	0.08
16	Relative humidity	%	+	0.015	35	50	41	25.45	35.45	55	40.45	30	30.5
17	Air temperature	0C	+	0.017	18	16	17	20	18	18	18	19	20
18	Luminosity	lux	+	0.018	80	65.45	60.5	90.5	110	100.55	90.5	95	110.9
19	Vibration	mm	-	0.01	0.06	0.07	0.1	0.06	0.07	0.06	0.06	0.1	0.05
20	Acoustic performance	dB	-	0.015	51	53	50	45	45	49	46	45	46
21	House dust mites	%	-	0.002	65	60	63	100	80	75	75	90	100
22	Dermotophagoides pteronysinus allergen	%	-	0.002	1	20	2	1	1	1	1	1	1
23	Noise pollution	dB	-	0.038	84.7	78	54.3	54.3	65.2	78	84.7	60.3	65.2
24	Carbon monoxide (CO)	μg/m³	-	0.017	7.13	4.12	0.21	0.28	1.51	4.12	7.13	0.66	1.51
25	Suspended particulate matter	μg/m³	-	0.017	0.069	0.047	0.001	0.001	0.003	0.047	0.069	0.022	0.003
26	Nitrogen oxide (NO_x)	μg/m³	-	0.017	59	56	49	52	51	57	60	50	49
27	Ozone	μg/m³	-	0.017	110	110	78	75	84	99	110	62	82

Fig. 5. Initial data for calculation of 2-room apartment mass appraisal value: upper part of matrix (*left*); lower part of matrix (*right*)

rately in each section near streets, in the middle and near the river (see Fig. 4), it was noted that air pollution as well as noise level significantly decreased with the distance from the street. For example, in the Žirmūnai area air pollution decreased by up to 40% when moving closer to the river, while in Antakalnis the same value amounted to 30%. Air pollution also depended on the type of pollution. For example, the content of solid particles in the air while receding from the street decreased fairly rapidly and approached the zero value, i.e. from 0.073 μg/m³ (maximal value) to 0.001 μg/m³ (minimal value). Table 2 gives more information on air pollution and noise in the Žirmūnai (A–A, B–B and C–C) and Antakalnis (D–D, E–E) sections near the street and near the river.

Air pollution and noise level obviously depended on the distance between the street and the river. More information on the sections (A–A, B–B, C–C, D–D, E–E), analysis of Table 2 and identified levels of air and noise pollution are available at the http://dss.vtu.lt/realestate/ website "Market-Based Land Mass Appraisal Online System for Land Taxation" section "Outside environment" subsystem.

Table 2. **Air pollution and noise in Žirmūnai (sections A–A, B–B and C–C) and Antakalnis (sections D–D, E–E) near street and river**

Section (see Fig. 4)	Distance from street to river	Number of buil-dings in section	Air pollution							Noise			
			Measuring units	CO			Solid particles			Measuring units	Near street	Near river	Alteration every 10 m
				Near street	Near river	Alteration every 10 m	Near street	Near river	Alteration every 10 m				
A–A	500	10	µg/m³	7.13	0.66	0.129	0.069	0.022	0.0009	dB	84.7	60.3	0.5
B–B	300	6	µg/m³	2.94	0.21	0.091	0.076	0.001	0.0025	dB	79.5	54.3	0.84
C–C	100	2	µg/m³	4.97	0.28	0.469	0.057	0.001	0.0056	dB	83.2	54.3	2.89
D–D	320	4	µg/m³	4.12	0.92	0.1	0.047	0.001	0.0014	dB	78	61.3	0.52
E–E	200	9	µg/m³	4.12	1.51	0.1305	0.047	0.003	0.0022	dB	78	65.2	0.64

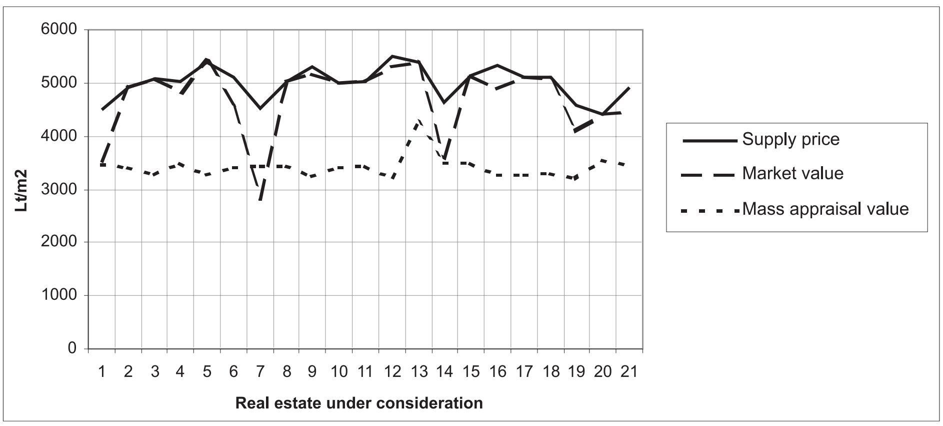


Fig. 6. Graphical comparison of supply price market value and mass appraisal value of 2-room apartments

Therefore, given such significant air pollution and noise alterations it is possible to make an assumption concerning the impact of these factors on real estate prices, i.e. the real estate market values closer to the street should be somewhat lower than near the river. Consequently, the real estate in question was grouped according to its proximity to the river and street. In parallel, data were gathered on its supply prices, market values and mass appraisal values. When comparing supply prices of real estate located near the street and near the river, our task was to determine whether air and noise pollution were taken into account when selling or buying property. We founds that the price differed depending on the property location. Therefore we can make a conclusion that air and noise pollution exerts a rather sizeable influence on property prices, and owners are aware of it.

Figure 6 graphically compares the supply price, market value and mass appraisal value of 2-room apartments. Supply prices and initial data for calculation of 2-room apartments' market and mass appraisal values by LMAS-LT were submitted by real estate broker companies, whereas official mass appraisal values of these apartments were estimated by the State Enterprise Centre of Registers. The market values of the real estate were calculated after the LMAS-LT database had been supplemented with new data–criteria of indoor microclimate (volume flow, air velocity, air temperature, relative humidity, dew point temperature, vibration impulse amplitudes), indoor allergens (house dust mites and *Dermatophagoides pteronysinus* allergen) and the outdoor environment (noise pollution, carbon monoxide (CO), suspended particulate matter, nitrogen oxide (NO_x), ozone). Figure 6 on its horizontal axis represents 21 apartments located in the zone under analysis, while the vertical axis shows the property price per 1 m^2. The continuous curve reflects a 2-room apartment supply price, the dotted curve stands for mass appraisal value calculated by the State Enterprise Centre of Registers, whereas the dashed curve displays a market value calculated accounting for additional criteria with the help of LMAS-LT.

The property market value calculated with the help of LMAS-LT relies on more criteria than the value presented by the State Enterprise Centre of Registers. LMAS-LT employs multiple criteria analysis and considers not only traditional criteria that describe a property, but also the indoor microclimate, allergens in the dwelling and air, and noise. The additional criteria enable a more precise evaluation of the market value of these apartments, which in turn helps assessing their mass appraisal value. According to the currently valid methodology, in Lithuania the market and the mass appraisal values are equal. Of course, the mass appraisal values calculated by LMAS-LT and the State Enterprise Centre of Registers differ. The mass appraisal values calculated by the State Enterprise Centre of Registers are considerably lower than the values obtained with the help of LMAS-LT. Thus, adopting additional criteria that describing the indoor microclimate, allergens in the dwelling and air, noise, and employing the methods of multiple criteria analysis developed by the authors it is possible to assess mass appraisal values more precisely.

CONCLUSIONS

There are various approaches to and different priorities of sustainable urban development in different countries. It is not surprising, because there are very divergent views and interpretations in various countries – those that have developed market economies, those with transition economies, and in developing countries. Different criteria systems (political, economic, social, cultural, institutional, technological, environmental, legal / regulatory and educational) characterize sustainable urban development. In order to select the best alternative, on forming the grouped decision-making matrix, it is necessary to perform a multiple criteria analysis of the alternatives. This is done by comparing the weights and the numerical values of criteria and analysing the conceptual information of the alternatives. The alternatives can be described only on the basis of a system comprising many criteria with different values and dimensions. Such a variety of criteria makes it difficult to compare the projects directly. The above problems and their solution are discussed in the paper.

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Edmundas Zavadskas, Artūras Kaklauskas,
Jonas Šaparauskas, Darius Kalibatas

VILNIAUS DARNAUS VYSTYMOSI ĮVERTINIMAS TARŠOS POŽIŪRIU

Santrauka

Darnus vystymasis — tai ilgalaikė nuolatinė visuomenės plėtra, siekiant tenkinti žmonijos poreikius dabar ir ateityje, racionaliai naudojant bei papildant gamtos išteklius, išsaugant Žemę ateities kartoms.

Siekiant nustatyti darnią miesto vystymosi strategiją siūloma ją vertinti pagal tam tikrus rodiklius. Toks miesto darnos rodiklių sąrašas yra negalutinis, nes miesto vystymasis priklauso nuo šalies politinės, ekonominės, socialinės, kultūrinės, institucinės, technologinės, aplinkos, teisinės ir švietimo situacijų, kurios tarpusavyje persipina ir glaudžiai susijusios. Kiekvienais metais pasiūloma šimtai naujų socialinių, ekonominių ir aplinkos rodiklių. Siekiant lengviau ir sparčiau parinkti pagal nustatytus rodiklius miesto darnaus vystymosi strategiją, turi būti taikomi sprendimų priėmimo metodai. Straipsnyje nagrinėjama rodikliai miesto darnaus vystymosi strategijai parinkti ir miesto darnaus vystymosi strategijos kokybės vertinimo metodai. Analizuodami Vilniaus darnųjį vystymąsi, autoriai ypač daug dėmesio skiria šiems rodikliams: transporto sukeliama tarša, triukšmas, patalpų vidaus mikroklimatas ir alergenai. Išnagrinėjus statistikos duomenis apie Vilniaus miesto gyventojų sergamumą buvo nustatyta oro užterštumo įtaka žmogaus sveikatai, tikimybei susirgti tam tikromis ligomis ir nekilnojamojo turto kainai. Atsižvelgiant į transporto srauto rodiklius siūlomi oro taršos, kylančios nuo transporto priemonių, mažinimo būdai.

Raktažodžiai: miesto darnus vystymasis, tarša, sprendimų priėmimas, pavyzdžiai