

# Sustainable development assessment of cities and their residential districts

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The aim of this study was to assess the sustainable development of Vilnius residential districts. To this end, a thorough analysis of scientific articles, specific databases and other information sources was made, different indicator systems for assessment of sustainable urban development were reviewed and a system of 22 indices defining the aspects of sustainability was compiled. Residential areas were evaluated for their facilities, residential and business environment. On the basis of the surveys performed by experts, the significance of the indices was determined. Application of the multipurpose evaluation method COPRAS (Complex Proportional Assessment) allowed to establish the rank of priorities of residential areas in respect of their sustainability. The results of such assessment may be helpful for city authorities in distributing resources among the wards in a more rational way.

**Key words:** sustainable development, residential areas of the city, indicators, COPRAS, evaluation

## INTRODUCTION

A city is a complex physical and social phenomenon that is under constant development. Quantitative and qualitative changes take place there. For various reasons the number of cities' inhabitants grew up from 3 to 50 per cent in the world. According to forecasts of the United Nations, in year 2030 the number of urban population will reach 60 per cent all over the world.

Cities concentrate manufacture, trade and service industries. Most people spend the larger part of their life in urban areas. Consequently, cities have become an integral part of modern civilization. They shape people's social, economic and cultural lifestyle.

The welfare of the whole society depends on the sustainability of urban development. Urban sustainability can be characterized by social, economic, environmental and engineering-technical indicators. However, while assessing the sustainability of cities and their residential districts the question arises which characteristics of sustainability should be evaluated.

For instance, the objects of the research chosen by Nijkamp and Ursen (1998) are pollution of water and atmosphere, also consumption of energy in a sustainable city. Brenheny and Archer (1998) concern with urban density, the influence of local authorities on sustainable development, also on the problems of communication among the residential districts. Banister (1998) characterized obstacles that hinder sustainability in a city. Diepen and Voogd (2001) studied the peculiarities of urban transport planning in a sustainable city. Henn and Henning (2002) analysed the indicators of economic, social and environmental sustainability. According to authors, there is a need to improve the performance of such indicators. Dalhuisen et al. (2002), by comparing five European cities, compiled a solid structure for

appraisals, estimated the level of sustainability and made suggestions on how to solve water supply problems in cities. Zhang et al. (2003) analysed sustainable urban development indicators. The research object chosen by Kountouris et al. (2005) is sustainable development of cities' environment. Bagaen (2006) examined the influence of military bases on urban sustainability. Turskis et al. (2006) developed a methodology that can help city planners to determine and localize problems of urban fabric density, to enhance the motivation and versatility of decisions. Melchert (2007) analysed building ecology and urban sustainability planning problems in developing countries.

Giving the multiplicity of sustainability characteristics, the problem of their inconsistency appears. To evaluate a great number of indicators it is necessary to apply multiple criteria optimization methods.

## SYSTEMS OF INDICATORS OF URBAN SUSTAINABILITY ASSESSMENT

### Indices defining a sustainable city

In order to evaluate urban sustainability, system of indicators should be compiled. In the world, different indicator systems characterizing urban sustainability have been developed.

Based on the conceptual framework of the urban ecological economic system (Huang et al., 1998), 80 indicators have been selected through participation in non-government organizations (NGOs), which can be used as policy-making indicators for measuring Taipei's urban sustainability. These are natural area, biodiversity, area productivity, population density, housing vacancy, fossil fuel use, per capita GDP, etc. The policy-making indicators have been further aggregated into ten general public indicators.

Atkisson (1996) describes the developing of indicators of sustainable community. At first, a total of 99 indicators had been recommended by the stakeholders. Since nearly everyone agreed that such number of indicators was too large a set for the public to digest, it was agreed to let a technical review group winnow the list down to a manageable number. This group, formed of members, met several times over the winter of 1992–93, eliminating indicators that were unmeasurable or difficult for a lay person to understand. The result was a final list of 40 indicators grouped into five categories: 1) Environment (biodiversity, soil erosion, air quality, etc.); 2) Population and Resources (population growth, residential water consumption, renewable and nonrenewable energy use, etc.); 3) Economy (real unemployment, distribution of personal income, health care expenditures, etc.); 4) Youth and Education (adult literacy, high school graduation, juvenile crime, etc.); 5) Health and Community (equity in justice, gardening activity, perceived quality of life, etc.).

The indicators to measure quality of life in Bristol (McMahon, 2002) were grouped under 14 sustainability topics such as waste management (total domestic waste, domestic waste recycled, etc.) energy (energy rating of council housing, average carbon dioxide emissions from council, etc.), transport (traffic flow, car ownership, etc.), environmental protection (days of moderate or poor air quality in Bristol, rivers of good or fair quality, etc.), biodiversity (sites of nature conservation interest, local nature reserves, etc.), housing and shelter (demand for re-housing, homeless households, etc.), sustainable business (Bristol businesses actively engaged in measurable environmental improvement, share of eco-labelled, organic or fair trade products in total consumption, etc.), health and well-being (families with health needs, population dissatisfied with the neighbourhood, etc.), community safety (fear of crime, children on child protection register, etc.), social economy (jobs in the social economy in Bristol, number of social economy organisations, etc.), culture and tourism (total visitors to museums, access to green space and services, etc.), land use and development (reuse of wasted homes, listed buildings at risk, etc.), education and poverty (citizens with no educational or technical qualifications, primary school achievement, etc.).

A set of indicators was developed for benchmarking cities of the world: Tokyo, Hong Kong, Singapore, Taipei and Shanghai (Ng and Hills, 2003). Global and local developments represent the following indicators: number of foreign governments represented, exports in million USD, imports in million USD, number of offices of international banks, average number of hours worked per annum, etc. Adult literacy rate, death rate per 100,000 population, proportion of journeys using public transport and other indicators cover human, social, cultural and environmental developments.

May et al. (2000) presented numerical indicators to measure economic and social conditions. They were accepted by many national and international agencies, including the World Bank and the United Nations.

The Encyclopedia of Urban Environment-related Indicators (2005) presents a matrix of core indicators (29) in the context of various indicator sets, core and city-specific indicators (90) in alphabetical order. The indicators can be grouped by CEROI issues.

Sustainable Measures (2005) develops indicators that measure progress toward a sustainable economy, society and environment. The indicators are grouped into the following categories: Economy, Education, Environment, Government, Health, Housing, Population, Public Safety, Recreation, Resource Use, Society, Transportation. For instance, Housing indicators have sub-categories such as Availability, Condition, Cost. Under the heading “Condition” stand: Floor area per person in housing, Low-income housing with severe physical problems, Percentage of dwellings in need of major repair, Housings that are inadequate, overcrowded, or cost over 30% of income.

The indicator system (Šaparauskas, 2003) for three alternative future scenarios of Vilnius has been developed. The system consists of twelve social, economic and environmental indicators. For example, environmental indicators are: NO<sub>x</sub> and particulate matter emissions exceeding healthy levels, surface water quality, green areas per inhabitant, percentage of waste recycled.

Zavadskas et al. (2005) proposed an indicator system for sustainability evaluation of city neighborhoods. This system characterises business environment, quality of life and infrastructure.

#### Indices defining a sustainable residential area

Sustainable development is becoming a dominating principle in planning a new and compact format of a city residential area. Awareness of impossibility to live in such residential areas as we have now forces us to reconsider our present practice of city planning. Acceptance of new and innovative ideas in the process of city planning is a new challenge for development of sustainable landscape.

A sustainable district should satisfy the requirements of sustainable development, embracing ecological, social, construction and traffic aspects. Its facilities are coordinated and handy to all residents (The Sustainable Region Initiative, 2005).

Residential areas are defined by economic, ecologic, social, technical, engineering indices. These issues were discussed in a number of publications.

The initiative committee of a sustainable district points out the following indices defining a sustainable district (The Sustainable Region Initiative, 2005):

- water;
- land use / agriculture;
- transport;
- buildings / facilities;
- business / industry;
- composting / processing;
- community / education;
- parks / green areas.

The European Academy of Urban Environment provides a model of sustainable district development (European Academy of the Urban Environment, 2005):

- balance between work and leisure time;
- nature preservation;
- priorities for pedestrians, cyclists and public transport;
- economic operation of energy generation and heating systems;
- construction of energy saving houses;
- opening of district supermarkets to satisfy everyday needs;

- opening of elementary schools and day centers;
- opening of public rest places in nature;
- diversity of forms of constructed buildings;
- arable land and agriculture
- balance among social groups.

In Lithuania, sustainable district projects have not been developed as much as abroad. Development of sustainable district projects requires a lot of efforts and means as well as financing by state institutions, nevertheless establishment of a sustainable district is beneficial to all residents of the district in ecological and social aspects. Life in harmony with nature, the environment and surrounding people is essential for each individual, therefore development of a sustainable district is a major project.

Woodcock emphasizes the major aspects of a sustainable city residential area (Woodcock, 2000) which is characterized by:

1. Excellent city development and architecture.
2. Privileges for the residents.
3. Consideration of local characteristics and needs.
4. The possibility to acclimatize and change.
5. Care of public space and new house projects.
6. Maintenance and renovation of buildings of historic value.
7. Care of the design of such buildings for the benefit of society by seeking promotion from the private sector.
8. Enhanced quality of private territories.

Thus, it is essential to develop the spirit of a location by enhancing the quality of life. This may be achieved by developing of an effective public transport network, safe streets, city design, the retailing sector, landscaping (open space) network, local employment basis.

The concept of Kronsberg city development and landscape sustainable development (Hannover..., 2006) emphasizes the following aspects:

- description of large-scale social and ecological development concepts;
- overall development of the project and integrated planning process;
- innovatory structure of communications maintaining the process of development;
- education and curricula associated with sustainable development;
- participation planning processes by involving residents and other people.

There is no uniform system of a sustainable city residential area, therefore development of a system of indices of a sustainable city residential area shall consider the needs of the residents as well as the social, environmental and technical aspects.

## VILNIUS CASE STUDY: ASSESSMENT OF SUSTAINABLE RESIDENTIAL AREA DEVELOPMENT

### Selection of the study object

To analyze the sustainability of city residential areas, Vilnius was selected as the principal administrative center of Lithuania with the highest concentrated economic potential, the highest number of inhabitants and the leading political, economic, social and cultural centers.

Evaluation of the sustainability of Vilnius city residential areas was based on the RAIT survey of the Vilnius city (RAIT..., 2005).

Forty-one districts and parts of districts were intercompared. Vilnius residents aged 16–74 years took part in the survey. The survey was carried out by direct interviewing using questionnaire forms in which the interviewers recorded the respondents' answers.

In total, 2575 permanent residents of Vilnius took part in the survey (RAIT..., 2005).

To determine the most sustainable Vilnius residential area, 29 residential areas (neighborhood areas) of Vilnius were selected from the RAIT survey (Figure): Centras I, Centras II, Žvėrynas, Senamiestis, Naujamiestis, Šnipiškės, Žirmūnai, Žirmūnai II (Šiaurės miestelis), Antakalnis, Rasos, Naujininkai, Lazdynai, Karoliniškės, Viršuliškės, Šeškinė, Baltupiai, Santariškės, Verkiai,



Figure. District communities of Vilnius city municipality

Table 1. Sustainable residential district data (fragment)

No.	Evaluation criteria	Unit of measure	Grigiškės	...	Žvėrynas	Senamiestis	Naujamiestis	Antakalnis	Rasos	Karoliniškės	Šnipiškės	Baltupiai	Santariškės	Pašilaičiai	Pilaitė II	Valakampiai	Pilaitė I
1	City center is close	Points	3.8	...	5	4.9	4.9	4.7	4.5	4.2	4.8	4.3	3.4	3.3	3.5	3.4	3.1
2	Extensive supply of trade services	Points	3.4	...	3.3	3.6	4.2	3.6	2.3	4.4	4.6	4	3.7	4.2	2.5	2.2	3.1
3	School is close	Points	4.4	...	4.8	4.6	4.5	4.6	3.6	4.8	4.8	4.5	3.8	4.6	3.1	2.7	4
4	Kindergarten is close	Points	4.5	...	4.9	4.4	4.4	4.1	3.6	4.9	4.8	4.4	1.9	4.6	2.8	3.1	3.7
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
19	No derelicts are in sight	Points	3	...	2.5	2.7	2.5	2.3	3.8	2.1	2.5	2.8	3.2	3.3	2.1	3.4	3.3
20	Work place is close	Points	3.3	...	3.7	3.9	3.8	2.9	3.3	3	3.8	3.1	2.9	3.2	3.8	2.6	3.2
21	Nice architecture of buildings	Points	2.9	...	3.7	4.5	3.3	2.9	2.7	2.4	3.3	2.8	3.2	2.9	2.5	3.4	2.8
22	Well attended parks	Points	3	...	4	3.2	3.3	3.4	2.6	3.3	3.3	3.2	3.3	2.6	3	3.5	3.5

Naujoji Vilnia, Žemieji Paneriai, Aukštieji Paneriai, Justiniškės, Pašilaičiai, Pilaitė II (Northern part), Valakampiai, Pilaitė I, Fabijoniškės, Vilkipėdė, Grigiškės.

The RAIT survey evaluates the Vilnius residential area by 22 indices that correspond to sustainability aspects (see Table 1): city center is close (points); safe (points); extensive supply of trade services (points); school is close (points); kindergarten is close (points); extensive supply of recreation (points); clean air (points); nice environment (points); good transport service with the center (points); good transport service to the work place (points); well attended environment (points); no noise (points); no drug-addicts (points); policlinic is close (points); drugstore is close (points); Good facilities for sports (points); many cultural institutions (points); no alcohol addicts are in sight (points); no derelicts are in sight (points); work place is close (points); nice architecture of buildings (points); well attended parks (points).

All these indices were taken from the RAIT survey (RAIT..., 2005) in which the residents evaluated the desirability of a residential area in points (5 points – excellent, 4 points – very good, 3 points – good, 2 points – bad, 1 point – very bad).

#### Determination of the residents' opinion compatibility

To determine the significance of the criteria, the expert judgement method proposed by Kendall (1970) was used. Zavadskas et al. (1987) discussed the application of this method in the field of construction.

On determining the numerical values of the indices their insignificance (importance) is determined. The significances of the indices of sustainability of city residential areas are evaluated in numerical scale from 1 to 22: 1 – insignificant index, 22 – very significant index (Table 2).

Forty-five residents of Vilnius were interviewed to determine the significance of the project indices. The residents had sufficient information about their residential area and were most concerned persons in establishing the value of sustainability of a city residential area.

This expert judgement method was implemented by the following stages (Zavadskas, 1987):

Table 2. Significance of evaluation criteria

No.	Evaluation criteria	Significance points
1	City center is close	0.042
2	Extensive supply of trade services	0.03
3	School is close	0.059
4	Kindergarten is close	0.034
5	Extensive supply of recreation	0.027
6	Clean air	0.071
7	Nice environment	0.061
8	Safe	0.069
9	Good transport service with the center	0.064
10	Good transport service with the work place	0.06
11	Well attended environment	0.047
12	No noise	0.068
13	No drug-addicts	0.048
14	Policlinics is close	0.035
15	Drugstore is close	0.045
16	Good facilities for sports	0.023
17	Many cultural institutions	0.016
18	No alcohol addicts are in sight	0.042
19	No derelicts are in sight	0.026
20	Work place is close	0.075
21	Nice architecture of buildings	0.044
22	Well attended parks	0.014

- interview
- calculation of values
- calculation of weights
- calculation of values
- calculation of values
- calculation of values
- calculation of values
- calculation of values
- testing the statement.

#### Evaluation of city residential areas by the COPRAS method

This method assumes a direct and proportional dependence of the significance and priority of investigated versions on a system

of criteria adequately describing the alternatives and on the values and significance of the criteria.

Application of the multipurpose evaluation method COPRAS allowed to establish the rank of priorities of residential areas in respect of their sustainability.

The description of the COPRAS method and the possibilities of its application have been presented in a number of papers (Zavadskas and Vilitienė, 2004; Vilitienė and Zavadskas, 2003; Zavadskas et al., 2001; Zavadskas et al., 2004; Kaklauskas et al., 2005; Andruškevičius, 2005).

Determination of the significance and priority of alternatives is carried out in four stages (Zavadskas et al., 1999):

- the weighted normalized decision-making matrix is formed;
- the sums of weighted normalized indices describing the version are calculated. The versions are described by both minimizing and maximizing indices;
- the significance (efficiency) of comparative versions is determined on the basis of the positive (“pluses”) and negative (“minuses”) characteristics;
- priority determination of a residential area.

On making calculations, we got sustainable residential areas of the Vilnius city: Žvėrynas, Centras II, Baltupiai, Senamiestis, Pilaitė I, Pilaitė II, Santariškės, Naujamiestis, Pašilaičiai, Antakalnis, Valakampiai, Grigiškės, Rasos, Karoliniškės, Šnipiškės, Šeškinė, Fabijoniškės, Centras I, Lazdynai, Naujoji Vilnia, Justiniškės, Žirmūnai II, Viršuliškės, Naujininkai, Verkiai, Žemieji Paneriai, Žirmūnai, Aukštieji Paneriai, Vilkipėdė.

## CONCLUSIONS

- There are a large number of indicators and indicator systems characterizing sustainable urban development in the world. The selection of indicators (indicator systems) used for assessment depends on the statistical data documented in a particular city.
  - Using the multipurpose evaluation method COPRAS, the most sustainable residential area were determined and evaluated by 22 sustainability development indices.
    - The ranking of priorities of Vilnius residential areas was as follows: Žvėrynas, Centras II, Baltupiai, Senamiestis, Pilaitė I, Pilaitė II, Santariškės, Naujamiestis, Pašilaičiai, Antakalnis, Valakampiai, Grigiškės, Rasos, Karoliniškės, Šnipiškės, Šeškinė, Fabijoniškės, Centras I, Lazdynai, Naujoji Vilnia, Justiniškės, Žirmūnai II, Viršuliškės, Naujininkai, Verkiai, Žemieji Paneriai, Žirmūnai, Aukštieji Paneriai, Vilkipėdė.
      - The proposed methodology allows assessing the development inequalities of particular residential areas, signalizes about the neighbourhood to be managed better. The results of such assessment may be helpful for the city authorities in distributing resources among the wards in a more rational way.

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Edmundas Zavadskas, Milda Viteikienė, Jonas Šaparauskas

### MIESTŲ IR JŲ GYVENAMŪJŲ RAJONŲ DARNAUS VYSTYMOSI ĮVERTINIMAS

#### Santrauka

Autorių pasirinktas tyrimų objektas yra miesto darnos vertinimo problemos. Atlikta išsami mokslinių straipsnių, duomenų bazių ir kitų informacinių šaltinių analizė, apžvelgtos įvairios darnaus miesto vystymosi įvertinimo rodiklių sistemos. Autoriai iškėlė sau tikslą įvertinti Vilniaus gyvenamųjų rajonų vystymosi darną. Šiam tikslui sudaryta 22 rodiklių, apibūdinančių darnos aspektus, sistema. Gyvenamieji rajonai buvo vertinami pagal verslo, gyvenimo sąlygas juose. Ekspertiniu būdu nustatyti rodiklių reikšmingumai. Daugiatiksliu kompleksiniu proporcingo įvertinimo metodu COPRAS sudaryta miesto gyvenamųjų rajonų darnos prioritetinga eilutė. Miesto valdžia, remdamasi tyrimo rezultatais, gali racionaliau paskirstyti išteklius administraciniam rajonams.

**Raktažodžiai:** darnus vystymasis, miesto gyvenamieji rajonai, rodikliai, COPRAS, įvertinimas