

# ASSESSMENT OF THE SUSTAINABLE URBAN DEVELOPMENT LEVEL THROUGH THE USE OF INDICATORS OF SUSTAINABILITY

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## Abstract

In this paper the authors analyzed the evolution of four major cities of Romania between 2006-2008, with the goal to compare and rank them in terms sustainable development. To meet this goal, we have choosed indicators of sustainability at urban level, grouped in four categories (economic, social, environmental and natural resources). For each city was calculated an overall score. The comparation of these scores could be used to diferentiate the cities in terms of sustainability in each year and the evolution during a period of three years, and provides important informations about the measures that can be applied for future improvement.

**Keywords:** sustainable development, indicators, monitoring, city, comparison, ranking.

## 1. INTRODUCTION

The world is becoming an increasingly urban place. About 65% of the world's population is expected to live in cities until 2025 (Schell and Ulijaszek, 1999). The excessive urbanization is the source of many problems such as pollution, crime, housing, noise annoyance, congestion, shortages of fresh water and energy, etc. (Tanguay et al., 2010, Van Dijk and Mingshun, 2005). The problem of attaining urban sustainable development is thus an important challenge.

The sustainable development concept was defined by World Commission on Environment and Development as "development that meets the needs of the present, without compromising the ability of future generations to meet their own needs" (WCED, 1987). The necessity of the sustainable

development was highlighted at the World Summit of Rio de Janeiro in the summer of 1992, and it was resumed in 2002, at the World Summit in Johannesburg..

Measuring the sustainability in urban areas – which are crucial engines of local socio-economic development, but at the same time present concentration points of environmental decay – is a major challenge for environmental managers and decision-makers. (Moussiopoulos et al., 2010). Sustainable development indicators are a solid base for the regular and long term monitoring of the progress registered in the achievement of strategic objectives of sustainable development and the evaluation of various aspects of sustainability (Hernández-Moreno and De Hoyos-Martínez, 2010, Ghiga, 2000). They are an indispensable tools for establishing the strategy and policy development, giving a representative image of the three dimensions of sustainable development: society, economy and environment

Many authors (Scipioni et al., 2009) suggest that the adoption of suitable indicators is fundamental to implement sustainable development at the urban level. The use of evaluation indicators and a method for assessing the status of urban sustainable development is required to support urban ecological planning, construction, and management (Li et al., 2010, Hernández-Moreno, 2010). With sustainability as the goal, the use of indicators for urban monitoring and regulation is becoming more and more in demand (Repetti and Desthieux, 2006).

At international level there are few researches concerning sustainability at city level. Some examples are the studies realized for the cities of Shanghai (Yuan et al., 2003) and Jining (Li et al., 2009) in China, Taipei (Huang et al., 2009) , Granada (Luque-Martinez and Muñoz-Leiva, 2005) and Padua (Scipioni et al., 2009).

In 2008, in Romania, was published the index of sustainable society (Mocanu-Perdichi, 2009), which analyses the current level of sustainable development in eight development regions of Romania. Until present, in Romania hasn't been done such a study at the city level, so the authors have proposed to assess the urban sustainability in four major cities (including the capital of the country) and to rank the cities in terms of sustainability in the period of 2006, 2007 and 2008.

## 2. THE RESEARCH METHODOLOGY

In the following we analyse the current level of the sustainable development of four Romanian cities highlighting the differences between this cities. The data used for the preparation of this study, are statistically data available at the national and local (municipal) level, which were then interpreted and compared.

For an easy assessment of sustainable development status, we used a set of 18 indicators grouped in four categories, as follows: 4 indicators for the economic dimension, 7 for the social dimension, 5 for the environmental dimension and 2 for natural resources. We have choosed the indicators we considered relevant for Romania.

These 18 indicators are:

#### **Economic indicators**

1. Gross domestic product per inhabitant (RON);
2. Occupied population per total population (%);
3. Unemployment rate of total population (%);
4. Number of passenger carried with public transport: trams, buses and minibuses, trolley-buses and underground (mill.);

#### **Social indicators**

5. Life expectancy (years);
6. Infant death per 1000 live-births (deaths under the age of 1 year per 1000 live-births) (‰);
7. Number of inhabitants per physician (persons);
8. Abandon rate in pre-university education (%);
9. Population density (person/sq.km);
10. Natural increase rates (live births rate-deaths rate/1000 inhabitants) (‰);
11. Living floor per person (sq.m/person);

#### **Environmental indicators**

12. Waste quantity generated per year per inhabitant (kg. waste/year/inhabitant);
13. SO<sub>2</sub> quantity emitted in the atmosphere annually ( $\mu\text{gr}/\text{m}^3$ ) (annual limit value=20  $\mu\text{gr}/\text{m}^3$ );
14. NO<sub>2</sub> quantity emitted in the atmosphere annually ( $\mu\text{gr}/\text{m}^3$ ) (annual limit value=43,35  $\mu\text{gr}/\text{m}^3$ );
15. CO quantity emitted in the atmosphere annually ( $\text{mgr}/\text{m}^3$ ) (limit value=10  $\text{mgr}/\text{m}^3$ );
16. Maximum noise level measured (dB);

#### **Natural resources**

17. Town verdure spots area (ha);
18. Drinking water supply (mill.m<sup>3</sup>).

As research methodology we have used the global utility method, which involves the choice of a decision based on multiple criteria. Table 1 represents the consequences table, in which  $V_i$  are the four analyzed cities : Bucharest, Iasi, Brasov and Constanta and  $C_j$  are the 18 indicators outlined above. The analysis was made for three years: 2006, 2007 and 2008.

## ASSESSMENT OF THE SUSTAINABLE URBAN DEVELOPMENT LEVEL THROUGH THE USE OF INDICATORS OF SUSTAINABILITY

TABLE 1 - CHARACTERIZATION OF CITIES IN TERMS OF INDICATORS<sup>1</sup>

C <sub>j</sub> \ V <sub>i</sub>	Bucharest			Iasi			Brasov			Constanta		
	2006	2007	2008	2006	2007	2008	2006	2007	2008	2006	2007	2008
C1 (RON)	35735,6	44365,5	60334,9	14964,4	17979,8	19205,7	18902,5	23841,3	28195,9	20449	22687	28650
C2 (%)	51,28	54,98	57,72	35,8	42,7	43,47	38,75	55,8	40,1	41,1	56,8	42,9
C3 (%)	1,17	0,946	0,94	0,9	1,12	0,99	1,28	1,73	1,22	1,8	1,51	1,2
C4 (mill)	1035,1	1027	972,7	79,15	106,241	84,89	73,393	67,895	64,076	95,62	111,556	78,947
C5 (years)	74,2	74,41	74,78	73,13	72,63	73,52	73,08	73,38	73,84	72,9	73,21	73,72
C6 (‰)	8,6	7,1	6,4	13,7	13,2	11,4	9,4	9,73	4,44	8,8	7,5	8,23
C7 (inhab.)	177	178	176	144,6	131,7	119,4	299,7	267,3	300,3	293,56	255,37	223,64
C8 (%)	5	5,5	5,8	5,5	4,8	6,6	6	7,1	6,9	4,8	5,3	5,3
C9 (inhab./sq. km)	8114	8154	8168	5143	3199,7	5054	1052,58	1039,75	1042,62	2446,55	2436,3	2420
C10 (‰)	-1,4	-1,3	-0,3	3,3	3,1	3,9	-1,76	-1,05	-0,63	-1,136	-1,4	-0,56
C11 (sq. m /inhab.)	15,76	15,85	15,85	13,3	13,4	13,6	14,03	14,18	14,23	13,78	13,799	13,799
C12 (kg./year /inhab)	462	470,18	482	364	325	367	450	450	450	346,2	376,8	405,16
C13 (µgr/m <sup>3</sup> )	18,02	18,5	12,8	7,9	6,68	6,7	5,1	5,6	5,6	17,1	16,2	13,3
C14 (µgr/m <sup>3</sup> )	128,2	108,5	78	34	32,15	35,5	40,5	42,3	42,2	36,2	34,7	14,9
C15 (mgr/m <sup>3</sup> )	1,75	2,15	0,79	0,9	0,68	0,5	0,66	0,68	0,41	0,81	0,49	0,46
C16 (dB)	88	86,4	86	83	95,3	91	90	78	94	84,1	96,6	92
C17 (ha)	1862	1862	1862	450	450	450	146	146	146	365	331	301
C18 (mill. m <sup>3</sup> )	212,783	215	237	36,965	36,862	37,082	23,611	22,437	21,028	26,607	23,922	25,058

The transformation of the values  $X_{ij}$  of Table 1 in utilities  $U_{ij}$  (Table 2 is the utilities table) allows the calculation of the global utility for each city and the ranking of them.

$$U_{ij} = \frac{C_{ij} - C_j^0}{C_j^1 - C_j^0},$$

where:

$U_{ij}$  – utility of the city  $i$  according the criteria  $j$ ;

<sup>1</sup> The data were collected from the following sites: [www.bucuresti.insse.ro](http://www.bucuresti.insse.ro), [www.iasi.insse.ro](http://www.iasi.insse.ro), [www.brasov.insse.ro](http://www.brasov.insse.ro), [www.constantina.insse.ro](http://www.constantina.insse.ro).

$C_{ij}$  – consequence of the city  $i$  according the criteria  $j$ ;

$C_j^0$  – the worst consequence;

$C_j^1$  – the most favorable consequence.

For example:

$$U_{31(\text{pt. 2006})} = \frac{18902,5-14964,4}{35735,5-14964,4} = 0,189$$

$$U_{42(\text{pt. 2006})} = \frac{79,15-73,393}{1035,1-73,393} = 0,006$$

TABLE 2 - CHARACTERIZATION OF CITIES IN TERMS OF UTILITIES

$V_i$ $C_j$	Bucharest			Iasi			Brasov			Constanta		
An	2006	2007	2008	2006	2007	2008	2006	2007	2008	2006	2007	2008
C1	1	1	1	0	0	0	0,189	0,222	0,218	0,264	0,178	0,229
C2	1	0,870	1	0	0	0,191	0,19	0,929	0	0,342	1	0,159
C3	0,7	1	1	1	0,778	0,821	0,577	0	0	0	0,280	0,071
C4	1	1	1	0,006	0,04	0,023	0	0	0	0,023	0,045	0,016
C5	1	1	1	0,177	0	0	0,138	0,561	0,253	0	0,325	0,158
C6	1	1	0,718	0	0	0	0,843	0,568	1	0,96	0,934	0,455
C7	0,791	0,658	0,687	1	1	1	0	0	0	0,039	0,088	0,423
C8	0,833	0,69	0,687	0,416	1	0,187	0	0	0	1	0,78	1
C9	0	0	0	0,42	0,696	0,437	1	1	1	0,802	0,803	0,806
C10	0,071	0,022	0,072	1	1	1	0	0,077	0	0,123	0	0,015
C11	1	1	1	0	0	0	0,296	0,318	0,28	0,195	0,162	0,088
C12	0	0	0	0,846	1	1	0,103	0,139	0,278	1	0,643	0,668
C13	0	0	0,065	0,783	0,916	0,857	1	1	1	0,071	0,178	0
C14	0	0	0	1	1	0,673	0,931	0,867	0,567	0,976	0,966	1
C15	0	0	0	0,779	0,885	0,763	1	0,885	1	0,862	1	0,868
C16	0,285	0,548	1	1	0,069	0,375	0	1	0	0,842	0	0,25
C17	1	1	1	0,177	0,177	0,177	0	0	0	0,127	0,107	0,09
C18	1	1	1	0,07	0,075	0,074	0	0	0	0,015	0,007	0,018

Considering that all criteria are equally important, for each city it is calculated the global utility, in each of the three years, summing the partial utilities.

Thus, in the year 2006, global utilities for the four cities are:

$$UG (\text{Bucharest}) = 1+1+0,7+1+\dots=10,68$$

UG (Iasi) =  $0+0+0+0,006+\dots\dots\dots= 8,674$

UG (Brasov) =  $0,189+0,19+0,577+0+\dots\dots\dots=6,267$

UG (Constanta) =  $0,264+0,342+0+0,023+\dots\dots\dots=7,641$

In 2007, global utilities for the four cities are:

UG (Bucuresti) = 10,788

UG (Iasi) = 8,636

UG (Brasov) = 7,566

UG (Constanta) = 7,496

In 2008, global utilities for the four cities are:

UG (Bucuresti) = 11,229

UG (Iasi) = 7,578

UG (Brasov) = 5,596

UG (Constanta) = 6,314

### 3. CONCLUSIONS

Analyzing the results and comparing the dynamic evolution of the four cities we found that:

- Bucharest, the capital of the country, had a sustainable evolution (as shows the Figure 1), both in the period 2006-2007, and especially during 2007-2008. In all of the three analyzed years, the indices calculated for Bucharest reached higher levels than any other city. Thus Bucharest was the first of the four cities, every year, at the indicators: gross domestic product per inhabitant, use of public transportation, life expectancy, living floor per person, town verdure spots area and the drinking water supply.

Instead, Bucharest gained the last position every year for four indicators: population density, waste quantity generated per year per inhabitant and NO<sub>2</sub> and SO<sub>2</sub> quantities emitted in the atmosphere annually. The main reason for these results is that Bucharest is the capital of the country, the city with the largest number of inhabitants, with the highest density/sq.km and the highest traffic.

- Iasi had an almost constant evolution, slightly decreasing in 2007 comparing to 2006 and, as shows the Figure 2, obviously decreasing during 2007-2008.

The indices calculated for Iasi, in all of three years, had recorder lower values than those calculated for Bucharest, thus Iasi city was the second in the ranking of four cities, after Bucharest, but not having a sustainable evolution.

Iasi was the first of the four cities every year at two indicators: number of inhabitants per physician and the natural increase rates, but gained the last place every year at three indicators: gross domestic product per inhabitant, infant death per 1000 live-births and the living floor per person.

- Regarding Constanta city, it had an unsustainable evolution in all the analyzed period (2006-2008). As shows Figure 3, the calculated indices for this city decreased from one year to another and recording lower values than those recorded in Iasi city.

Thus, in terms of index value, Constanta ranks on the third place in the years 2006 and 2008, after Iasi, and the fourth place in 2007, after Brasov.

In 2006 has obtained the highest values for the following indicators: abandon rate in pre-university education and waste quantity generated per year per inhabitant, but the lowest values for: unemployment rate and life expectancy. In 2007, Constanta has obtained the highest values compared to other cities at the indicators: occupied population per total population and CO quantity emitted in the atmosphere annually, but the lowest values at the indicators: natural increase rates and maximum noise level measured in the urban areas. In 2008, the maximum values were achieved by Constanta at the indicators abandon rate in pre-university education and NO<sub>2</sub> quantity emitted in the atmosphere annually, and the minimum values at the indicator SO<sub>2</sub> quantity emitted in the atmosphere annually.

- Regarding Brasov city, it had a sustainable evolution in 2006-2007 and an unsustainable evolution in 2007-2008. In 2006 Brasov obtained the lowest score of all cities. Thus Brasov was situated on the fourth place, after Constanta. In 2007 the index value was higher than in 2006, so is explained the sustainable evolution. In terms of 2007's value, Brasov was situated on the third place, after Iasi. However, in 2008, the index values are clearly decreased compared to 2007, as shows Figure 4. This explains the unsustainable evolution during 2007-2008.

However, in all three analyzed years, Brasov city obtained the best results at the indicators: population density (having so the smallest number of inhabitants/sq.km.) and the SO<sub>2</sub> quantity emitted in the atmosphere annually. But Brasov records the weaker results in the three years at the indicators: number of inhabitants per physician, abandon rate in pre-university education, town verdure spots area, drinking water supply and use of public transportation.

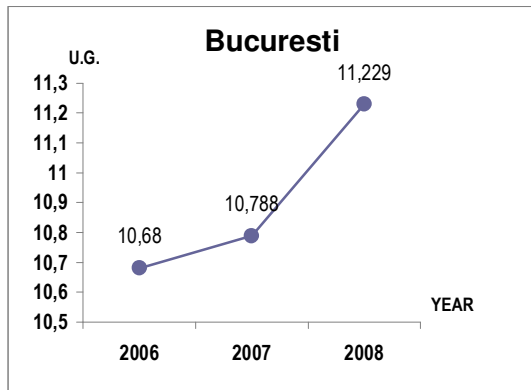


FIGURE 1 –THE INDEX EVOLUTION FOR BUCHAREST IN 2006-2008

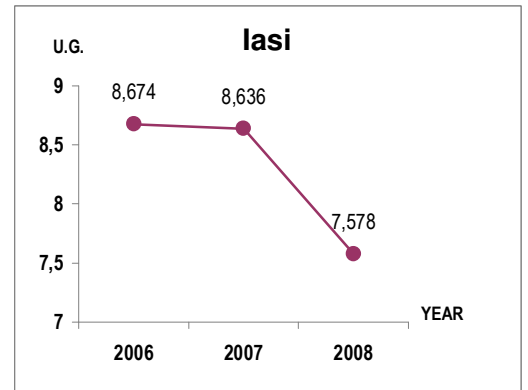


FIGURE 2 –THE INDEX EVOLUTION FOR IASI IN 2006-2008

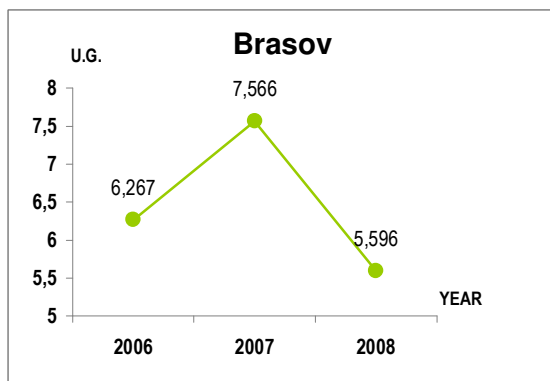


FIGURE 3 –THE INDEX EVOLUTION FOR BRASOV IN 2006-2008

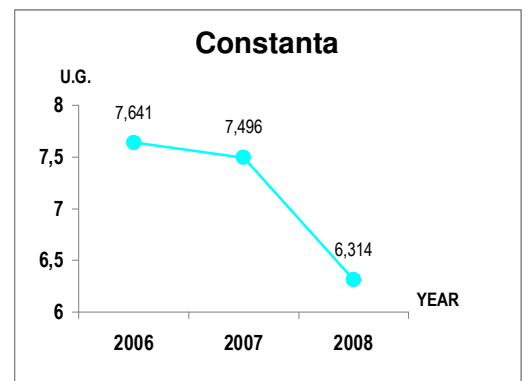


FIGURE 4 –THE INDEX EVOLUTION FOR CONSTANTA IN 2006-2008

Figure 5 shows the evolution of the indices for each city in each of the three years. From this graph we can see that only Bucharest had a sustainable development in all this period, recording at the same time the highest values of the calculated indices each year.

It also can be seen that Brasov had a sustainable evolution during 2006-2007, but however it ranks last place of the four cities each year.

The results are of real value, because they show the current status on the sustainability of each city, allowing their mutual comparison. The results could be useful for representatives of municipal



authorities, being also a starting point in identifying measures for improvement in the future, and being, in the same time, tools in the implementation of programs and plans regarding the sustainability of each analysed city.

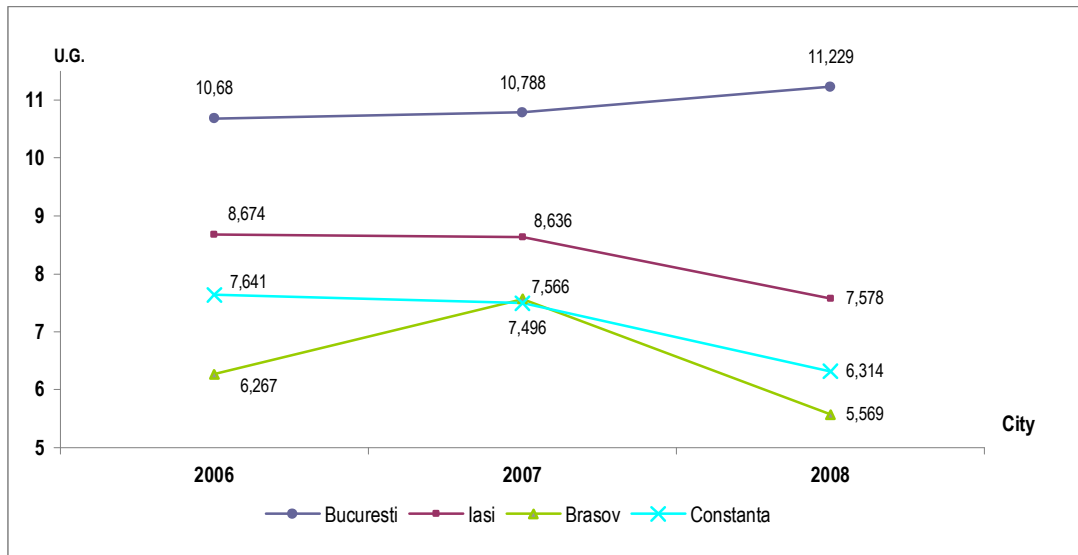


FIGURE 5 –THE INDEX EVOLUTION FOR ALL THE CITIES IN 2006-2008

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