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TOOLS TO DETERMINE THE DEGREE OF SUSTAINABLE DEVELOPMENT HARMONIZATION FOR INDUSTRIAL CITY

Abstract. This article provides tools to determine the degree of harmonization of sustainable development, in particular economic, environmental and social aspect and realized its practical application to the industrial city. Great attention was paid to the analysis of models that determine the relationship between sustainable development constituents and the method evaluation of the degree of sustainable development harmonization was presented.

Keywords: harmonization, instrumentation, industrial city, sustainable development

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JEL Classification: O10, O18, R11

Introduction. The basis of development of the most world countries is the concept of "sustainable development", which also combines three components: economic, environmental and social. Such symbiosis contributes to the quality of life for present and future generations, keeping the environment and social progress, which determines the level of human needs. The realities of economic life clearly demonstrate the need to identify a harmonious relationship between the components of sustainable development, which is important for the development of state programs and strategies. The value of each component can vary depending on the level of the economy, state, region, city.

At present a significant role in combating global challenges is given the city itself. The European experience shows that this urban development can provide a strong impetus for the creation of regional centers that can provide social progress and accelerate economic growth in general. Particular attention is given to the research of our industrial city, which is characterized usually by insufficient level of environmental component, due to the large concentration of industrial production. Therefore, it is necessary to harmonize development tools of components of sustainable development of the industrial city, which can be the basis for economic growth in the future.

Research and Analysis of assignment. Considering the importance of sustainable development as global trends, much attention is always paid to its research. Among the foreign researchers, paid special attention to this issue, should be distinguish: D.L. Medouza, D.N. Medouza, Y. Randersona, V. Berensa, G. Deili [Medouz, Randerson, Berens 2012]. Among Ukrainian scientists fundamental tenets of sustainable development set out in the works O. Bilorusa, A. Halchynskoho, V. Heietsia, M. Dolishnoho, L. Melnyka, L. Rudenka, V. Trehobchuka, M. Khvesyk, O. Shubravskoi [Bilorus 2006; Dolishnii 2002; Khvesyk 2012] and others.

The problems of local development, in general, and industrial cities, in particular, were examined by such scholars as: O. Boiko-Boichuk, I. Vakhovych, B. Danylyshyn, Z. Herasymchuk, O. Karyi, M. Mezhevych [Boiko-Boichuk 2002; Herasymchuk 2012; Danylyshyn 1999; Karyi 2010] and others.

One of the problems of urban development is the lack of harmony between its components. Therefore, the priority task for cities is not only to attract as many resources and their rational usage, but also to achieve harmonized relations between them. It will simalteniously increase the standard of living and improve the efficiency of the city.

Research results. In our study, according to the sustainable development, the concept of "harmonization" is used in the analysis of correlation between its components: economic, social and environmental components.

We calculated the value of the basic component of sustainable development of the industrial city (Zaporizhzhya).

We use the analytical framework of indicators for the evaluation of component of sustainable development of industrial cities Zaporizhzhia (tabl. 1).

Table 1 – The analytical framework of indicators in Zaporizhzhia to determine the indicators and index of sustainable development

Names	Current value	Minimumal value	Maximum value
1	2	3	4
Social indicators			
Density of population, per 1 км^2	2703	1073	3898
The number of unemployed, thousand. people	7,6	0,3	28,4
The number of employed persons	187611	1545	255422
The number of university students I and II levels of accreditation, person	4191	1780	7483
The number of students in higher educational institutions III-IV accreditation levels (state), person	37138	16436	53574
Number of reported crimes	6073	684	41804
The commissioning of housing area, m2	58861	294	101516
The number of preschool institutions, units.	143	10	522
The number of schools, units.	124	7	600
The number of vocational schools, units	17	1	46
Sanitation health and wellness institutions, units	15	1	225
Children's facilities and rehabilitation centers, units	29	2	264
Economic indicators			
Volume of industrial production, UAH.	86914287,6	13185	118921170,6
Monthly average nominal wages, UAH.	4470	2675	7559
Arrears of wages thousand. UAH.	27026,1	92,7	67236,1
Sales of products (goods and services), UAH	142812176,2	305828	181365185
Retail turnover, UAH	13909,9	296,5	22161,5
The amount of capital investment at current prices, UAH	5139	10	7794
Foreign direct investment, USD, USA	976260,5	606,1	1039760,3
Environmental indicators			
Pollutants and carbon dioxide emissions into the atmosphere from stationary sources of pollution, etc.	83264	104,7	193683,1

End of Table 1

1	2	3	4
Emissions of carbon dioxide and air pollutants from mobile sources and production equipment, etc.	31386,2	972	76694,1
Emissions of pollutants (excluding carbon dioxide) and greenhouse gases into the atmosphere from stationary sources of pollution, ths. Tons	83,3	0,1	193,7
Emissions of air pollutants from stationary sources of pollution on average one company,t. ie	408,2	6,5	9447,6
The density of pollutant emissions from stationary sources of pollution per 1 km 2 areas, etc.	299,5	3,3	1623,8
Pollutant emissions into the atmosphere from stationary sources of pollution, per capita, t	109,6	1,9	1910,2
Emissions of air pollutants from motor vehicles, tons	30,1	1,0	66,1
Waste I-IV classes of danger, t	3711299,8	6813,8	5463289,0

Source: developed by author Buriak V.

Table 1 as the actual values statistic relevant data is used for Zaporizhzhia, minimum values – the smallest value of regional towns. As a regional city, it is the largest industrial center in Zaporizhzhia region and it has a maximum value for the overwhelming majority of indicators. Statistics for the area, in a whole, are examined as the maximum qualitative indicators.

Valuation of sustainable indicators is performed as follows to determine the index (f.1):

$$I_z = \frac{Z_{fact} - Z_{\min}}{Z_{\max} - Z_{\min}}, \qquad (1)$$

where I_z - normalized indicator; Z_{fact} - The actual value of the index; $Z_{\max}$ - The maximum rate; $Z_{\min}$ - The minimum value of the index.

The results of the valuation of selected indicators are presented in Table 2.

Table 2 – The standardization of indicators of Zaporizhzhia to determine the index indicators and sustainable development

Names	Standardized values
1	2
Social indicators	
Population density, person per 1 км^2	0,577
The number of unemployed, thousand. people	0,254
The number of employed persons	0,733
The number of university students I and II levels of accreditation, person	0,423
The number of students in higher educational institutions III-IV accreditation levels (state), person	0,557
The number of reported crimes	0,131
The commissioning of housing area, m2	0,579
The number of preschool institutions, units.	0,260
The number of schools, units.	0,197
The number of vocational schools, units.	0,356
Sanitation health and wellness institutions,units	0,063
Children's facilities and rehabilitation centers, units.	0,103

End of Table 2

1	2
Economic indicators	
Volume of industrial production, UAH	0,731
Monthly average nominal wages, UAH	0,368
Arrears of wages thousand. UAH	0,401
Sales of products (goods and services), UAH	0,787
Retail turnover, UAH.	0,623
The amount of capital investment at current prices, UAH.	0,659
Foreign direct investment, USD, USA	0,939
Pollutants and carbon dioxide emissions into the atmosphere from stationary sources of pollution, etc.	0,430
Emissions of carbon dioxide and air pollutants from mobile sources and production equipment, etc.	0,402
Emissions of pollutants (excluding carbon dioxide) and greenhouse gases into the atmosphere from stationary sources of pollution, tons, ths	0,430
Emissions of air pollutants from stationary sources of pollution on average one company,ton ie	0,043
The density of pollutant emissions from stationary sources of pollution per 1 km 2 areas, etc.	0,183
Pollutant emissions into the atmosphere from stationary sources of pollution, per capita , ton	0,056
Emissions of air pollutants from motor vehicles, tons	0,447
Waste I-IV classes of danger, ton	0,679

Source: developed by author Buriak V.

To determine the components of sustainable development - social, economic, environmental we use formula of corresponding subindexes (f. 2-4):

$$I_{soc} = \sqrt[n]{\prod_{i=1}^{n} I_i^{soc}}\,, \tag{2}$$

$$I_{econ} = \sqrt[n]{\prod_{i=1}^{n} I_i^{econ}}\,, \tag{3}$$

$$I_{eco\log} = \sqrt[n]{\prod_{i=1}^{n} I_i^{eco\log}}\,, \tag{4}$$

where : n – the number of indicators are used to assess the indicator I_{soc}, I_{econ}, $I_{eco\log}$

For practical implementation of the proposed approach we calculate the index and sub index of sustainable development in general. We determine the subindex for Zaporizhzhia by formula (2)-(4):

$$I_{soc} = \sqrt[n]{\prod_{i=1}^{n} I_i^{soc}} = 0{,}245,$$

$$I_{econ} = \sqrt[n]{\prod_{i=1}^{n} I_i^{econ}} = 0{,}565$$

$$I_{eco\log} = \sqrt[n]{\prod_{i=1}^{n} I_i^{eco\log}} = 0{,}238$$

Based on the calculations, it should be noted, that the most important components of the economic index are 0,565.

Indexes of the environmental and social components are approximately the same, which is 2 times lower than the index of economic component. The given results indicate a lack of harmonization between the components of sustainable development and cause the need to find ways to achieve the harmonious state.

A significant concentration of industrial production is the peculiarity of the industrial city. The result is a strong burden on the ecological environment, which reinforces the importance of the environmental component without leveling the importance of economic and social development. Therefore, the urgent task is to find ways of harmonization between the components of sustainable development.

In scientific literature [Martynov 2014] sustainable development is reviewed as a system, which consists of certain elements, so called components. Analysis of relationship between components of sustainable development is based on the "principle of balance", which defines the relationship between model components of sustainable development (Fig. 1).

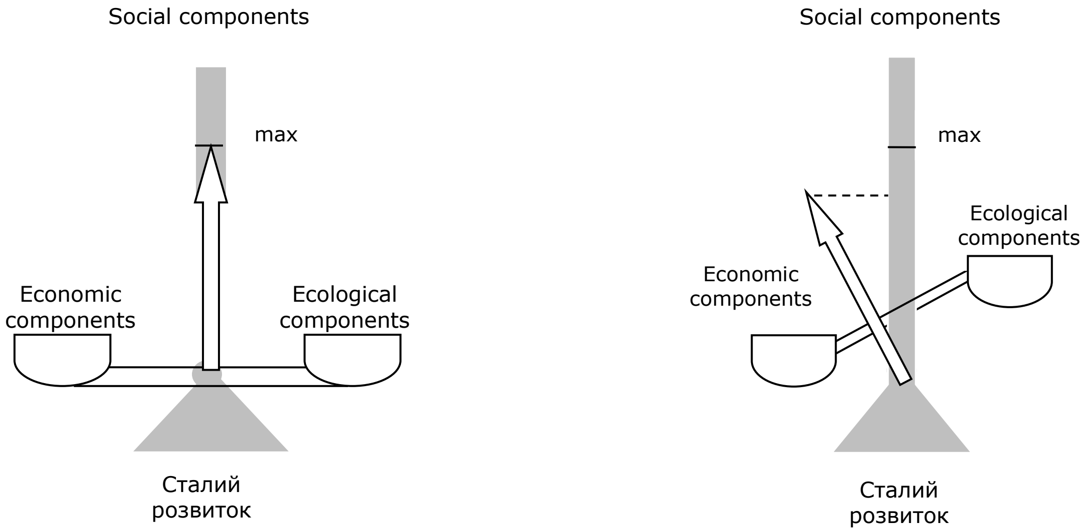
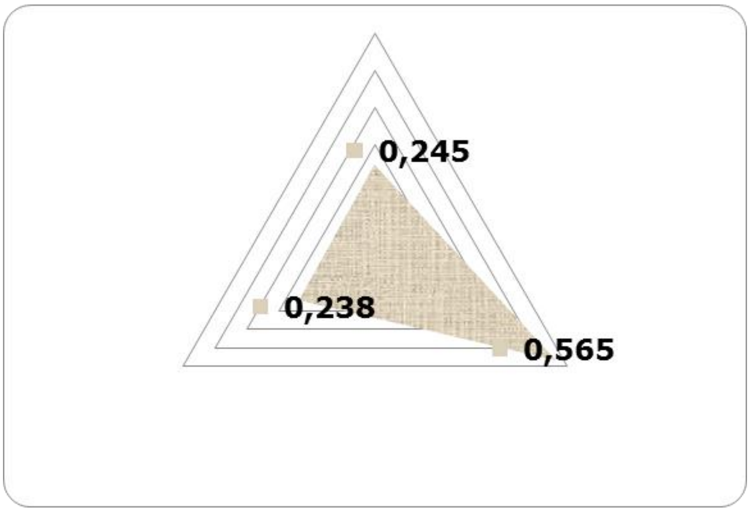


Figure 1 – Interconnection Model of components for sustainable development at a large industrial city

Source: developed by author Buriak V.

The model shown in Fig. 1 clearly shows that the ideal state is the balance between economic and environmental component that provides the necessary level of social development. In turn, the imbalance towards the predominance of economic or environmental component leads to the rejection of an adequate level of social welfare. It should be noted that at the present stage of development, the role of cities as levers of economic and social progress is based on the harmonization between the components of sustainable development. Assay components of sustainable development and analysis of the degree of harmonization will be considered on the example of industrial city (Zaporizhzhya). The practical implementation of the proposed approach can be considered by analyzing the actual components of the index of sustainable development (Fig. 2).



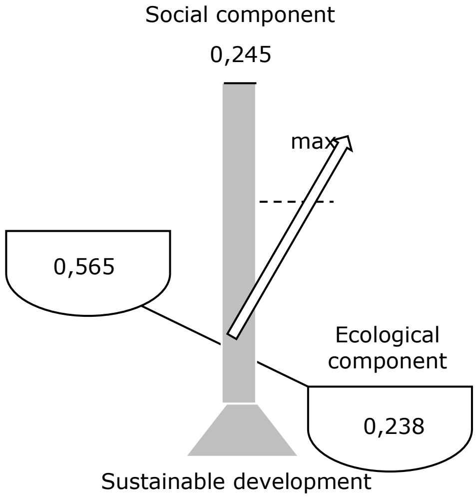


Figure 2 – The actual value of the index components of sustainable development
Source: developed by author Buriak V.

Graphic interpretation "principle of balance», shown in Fig. 2, indicates the breach for a large industrial city. A significant advantage of the economic components over social, shifts the balance to the right, and therefore, leads to inadequate levels of social welfare.

As a tool for assessing of the degree of harmonization of components of sustainable development of the industrial city, in our view, it is appropriate to use the formula for determining the distance between two points. This allows analytic dependence "to quantify" the degree of" lag "between the components of sustainable development and harmonization:

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad (5)$$

We use proposed analytical tools to assess harmonitsation between components of sustainable development, industrial city (Zaporizhzhya), considering that $I_{soc} = 0{,}245$ the economic component - $I_{econ} = 0{,}565$ ecological component - $I_{eco\log} = 0{,}238$

If this distance equals to three dimensions, it shows a significant level of harmonization between the sub-indexes and sustainability, otherwise there is a dominance of one or another component, and as a result of lack of harmony. If the index will dominate the economic component, it will lead to imbalance of the ecosystem and increases the likelihood of social conflicts due to deterioration in the level and quality of life, as evidenced by the significant backlog social component of sustainable development.

The level of "lag" between the components of sustainable development will be quantified as follows:

between *Isoc and Iecon:*

$$d_1 = \sqrt{(0{,}245 - 0)^2 + (0{,}565 - 0)^2} = \sqrt{0{,}37925} = 0{,}62$$

between *Isoc and Iecolog:*

$$d_2 = \sqrt{(0{,}245-0)^2 + (0{,}238-0)^2} = \sqrt{0{,}116669} = 0{,}34$$

between *Iecon and Iecolog:*

$$d_3 = \sqrt{(0{,}565-0)^2 + (0{,}238-0)^2} = \sqrt{0{,}375869} = 0{,}61$$

Using the "principle of balance" it can be concluded that the triad components of sustainable development forms an isosceles or equilateral triangle. If we consider the model of an isosceles triangle, the distance of the environmental and social and economic and social components should be equal. If there is an equilateral triangle equality for all distances: environmental, social, economic and social, economic and environmental components.

We'll analyze the important components of sustainable development for industrial city with models of isosceles consideration and an equilateral triangle. Equal distances "Isoc and Iecon" and "Isoc and Iecolog" should be modeled after an isosceles triangle.

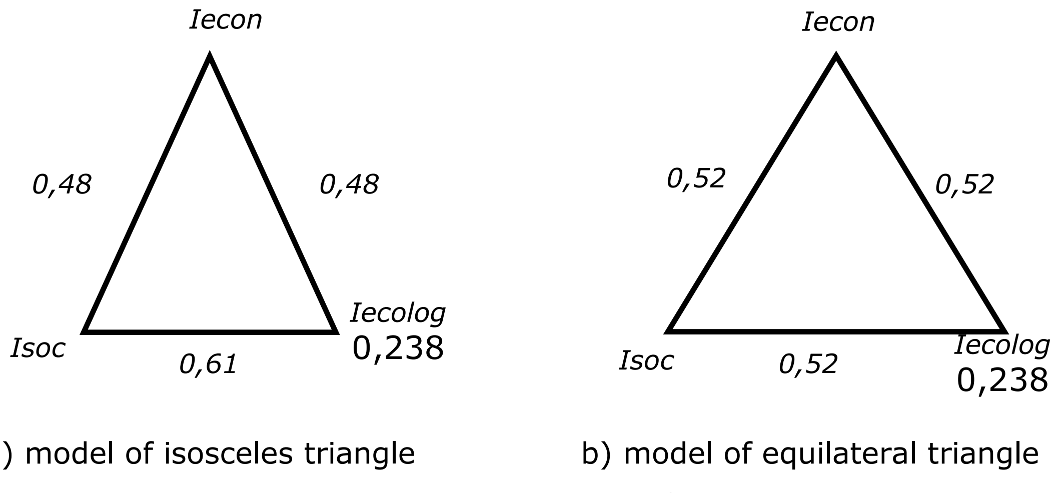
According to the results the distance "Isoc and Iecon" prevails on the distance of 0.26 "Isoc and Iecolog». The calculations confirm disharmony between components of sustainable development according to equilateral triangle model, according to which all distances are to be equal.

Based on the properties of isosceles and an equilateral triangle "ideal values" of components of sustainable development can be defined (Table. 3).

Table 3 – Actual and "ideal" values of distances between components of sustainable development for the city Zaporozhzhia

Distance	Model of isosceles triangle	Model of equilateral triangle
Isoc and Iecon	0,48	0,52
Isoc and Iecolog	0,48	0,52
Iecon and Iecolog	0,61	0,52

Using this approach, you can also determine the value of each of the components of sustainable development. We believe one of the important constituents known for example *Iecolog* = 0,238 and knowing the level of "lag" we indentify the rest of the Isoc and Iecon (Fig. 3).



a) model of isosceles triangle b) model of equilateral triangle

Figure 3 – Determining the "ideal" component of sustainable development
Source: developed by author Buriak V.

The calculation results for the model isosceles triangle and an equilateral triangle are presented in Table 4.

Table 4 – The component of sustainable development according to the model isosceles and an equilateral triangle

Distance	Model of isosceles triangle	Model of equilateral triangle
Iecon	0,561	0,462
Isoc	0,417	0,462
Iecolog	0,238	0,238

Comparative analysis of the component of sustainable development according to the model isosceles and an equilateral triangle (Table. 2) shows that there is a dominant economic component (0.561 and 0.462, respectively).

Environmental component has lowest value (0,238). Two models differ in that, if the rule model of isosceles triangle and an equilateral triangle environmental component value is higher than the rule equilateral triangle, while the social component is characterized opposite trend. Use of certain rules depends on what the ultimate goal of the industrial city.

So,given tools determine the degree of harmonization to allow graphical interpretation and make analyses of the nature of the relationship between the components of sustainable development.

Conclusions. It was given the tools to determine the degree of harmonization of components of sustainable development, including economic, environmental and social dimension and made it practical to use industrial city. Particular attention is paid to the analysis of models that define the relationship between the components of sustainable development and assessment methodology of the degree of harmonization of components of sustainable development.

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