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CHARACTERISTICS OF INDICATORS OF SUSTAINABLE DEVELOPMENT

ХАРАКТЕРИСТИКИ ПОКАЗНИКІВ СТАЛОГО РОЗВИТКУ

The article reveals the notion of sustainable development. The main criterion for the selection of indicators which has been considered is their important characteristics which are necessary for the establishment of a national assessment of informative system and the dynamics of sustainable development of the state. It is determined that the main characteristics of indicators are the following: possibility of quantitative measurement and comparison, compliance with international indicators of sustainable development and existence of additional specific indicators.

Keywords: *sustainable development indicators, strategy, environmental policy, economic and social development.*

Formulation of the problem. Basis of sustainable development at the state and regional level is to harmonize economic, social and environmental components. An important condition for this process is transition to "information" society and intelligence-oriented economy that allows economic growing in conditions of economy use of limited natural resources, improve the environment and achieving, on this basis, the interests of social development. Relationship and interdependence of economic, social and environmental issues and their impact on economic security actualize the need to improve the research methodology of sustainable development.

Analysis of recent research and publications. A lot of local and foreign scientists: H. Hom'yachenkova, T. Vazhenina, V. Harkavaya, O. Kushnarova, Y. Mihunov, V. Borysevych, Y. Kononova, A. Luk'yanov, A. Doholyan, O. Klymahina and others, devoted their scientific works to the problems of sustainable development and indicators of its complex measuring.

The scientists proposed indicators for numerous projects for the system of different scales: global, regional, national, local, industry, even for individual localities and enterprises. However, the issue of development sustainable indicators has an enormous amount of problems and contradictions yet.

Aim of the article is description and systematization of indicators of sustainable development, analysis of existing theoretical and methodological support evaluation of sustainable regional development and its further improvement within formation of national sustainable development strategies of the country.

Main material research. Nowadays there are many definitions of the term "sustainable development", due to complexity of the concept, which includes social, economic, environmental and other aspects of human development, with different, often conflicting views of scientists, researchers, entrepreneurs and politicians. In various countries a term "sustainable development" has acquired different interpretations. Sustainable development is development that generates economic growth, justly distributes his results, restores the environment to a greater extent than destruction of it, increases possibilities of people, not impoverish them [2].

According to V. Harkavaya, sustainable development – social and natural form of development, taking into account ecological and other global imperatives and being against to the economically deterministic unsustainable development presents system co-evolution of society and nature [3]. Sustainable development of society usually means development that used to establish a scientifically substantiated limit of population (people), provide all necessities for life and satisfaction of spiritual needs in conditions of naturally recreated habitat.

Let's review components of integral indicators for sustainable development. Most scientists calculate the integrated indicator of sustainable development for regions being based on economic, social and environmental component.

But in the method proposed by the Commission on sustainable development UN [4], there is also an institutional component, which characterizes institutional aspects of sustainable development - rights and information security, tools of government policy on sustainable development, the basic fundamentals with the formation of civil society.

Political component, which highlighted in [2], in sense similar to institutional and reflects political will of authorities to implement concepts of sustainable development into all areas of regional development.

In Goryana's research [1] presented the most complete list of components of integral index of sustainable development. Special infrastructural component coincides with the institutional, however, contains more specific indicators for the assessment of social infrastructure. An innovative component based on the indicators that characterize the level of STP in the region.

N. Homyachenkova [5] identifies specific components of development - sustainability risk, which is understood as ability of the object of research to link risk management processes development and define the pace of economic, social and environmental development.

T. Vazhenina [6] except classical components of sustainable development - economic, social and environmental component offers "financial component", which describes the region's financial subsystem using the following parameters:
- Value of budget revenues, % to previous year in comparable prices;
- Ratio of debt to budget revenues, %;
- Ratio of costs for municipal debt service expenditures, %.

Methods of calculation for integral index about sustainable development of the region, presented in scientific literature, differ not only in composition of components but also in system of partial indicators within the framework of every component and method of their integration.

So a methodical approach, proposed by I. Goryana [1], involves calculation of an integral indicator of sustainable development of the region by formula, which implies the equivalence of separate components for sustainable development of the region.

Garkavaya's methodology is traditional, where integral indicator of sustainable development of the region (Kint) is calculated as geometric medium value, which reflects proportionality between components:

$$\text{Kint} = \sqrt[3]{K_{econ} \cdot K_{soc} \cdot K_{ecol}} \, , \tag{1}$$

K_{econ}– integral indicator of economic development of the region;
K_{soc}– integral indicator of social development of the region;
K_{ecol}– integral indicator of ecological development of the region.

D. Ponomarev [7] linked geometric and arithmetic calculation for building integrated indicator for sustainable development of the region. According to this method, at the first stage there are collection and standardization of partial indicators totality of which is divided into stimulators and dissimulators. Standardization of stimulators calculates by this formula [7]:

$$A_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})} \, , \tag{2}$$

Aij– standardized value of the partial indicator of sustainable development of the region;
xij– standardized value of the partial indicator of sustainable development region.

Standardization of de stimulators by formula[7]:

$$A_{ij} = \frac{\max(x_{ij}) - x_{ij}}{\max(x_{ij}) - \min(x_{ij})} \, , \tag{3}$$

The formula for calculating the summary measure by each component of sustainable development has the form [7]:

$$K_{econ} = \frac{\sum_{i=0}^{n} B_{ik}}{n} \, , \tag{4}$$

Kecon – general indicator of economic development of the region;
Bik – the value of k-th economic indicator for i-th period;
n – number of indicators in the group.

Currently there are several options about calculation of indicators for sustainable development, which are based on two approaches. The first is formation of a single aggregated indicator; the second is construction of the system of indicators.

First approach is more convenient for decision making, because at output proceeds analysis of values for only one generalized indicator. The disadvantage is in using a number of methodological and statistical issues there are difficulties in calculating of indicator. The methodological problems include lack of unified international rules of calculation of aggregated indicators for sustainable development. Statistical problems are expressed in absence of necessary and reliable statistical base.

Index of real savings determines sustainability in broader terms than national or regional accounts. This indicator was intended to show value of clear change in whole spectrum of assets, which are important

to development: productive assets, natural resources, environmental quality, human resources and foreign assets. The index calculation takes place in two stages. The first stage is determined by amount of clear domestic savings in way of adjusting gross domestic savings on depreciation of production assets. The second stage – from clear domestic savings and charges on formation deduct the value of depletion of natural resources and damage from pollution.

The formula for calculating the index of real savings:

$$IDS = (GDS – D) + CF – DNR – DP, \qquad (5)$$

IDS – indicator of domestic savings;
GDS – gross domestic savings;
D – depreciation;
CF – charges on formation;
DNR – value of depletion of natural resources;
DP – damage from pollution.

Advantages of this methodology are that it can help to make a comparative analysis about the nature of development in different regions for single coordinate system. Increase in amount of domestic savings over several periods of time is evidence that the region has a sustainable way that minimizes the possibility of occurrence of negative effects in the long term. Among drawbacks of the approach can highlight difficulty of establishing in monetary terms value about depletion of natural resources and damages from pollution.

At the same time, there is a method of assessing the level of sustainable development of the region which using indicator "life expectancy – GDP per capita".

The advantage of these techniques is that they can be used to carry out complex estimation of development in the country as a whole or individual region, and also to make a comparative analysis between them. Another plus is relative availability of information that is needed for calculation of the integrated index. Usage of this technique in determining sustainability can lead to inaccurate conclusions, which is unacceptable.

A significant contribution to solution of the problem of assessment for sustainability was made by American scientists Cobb and Delhi, who proposed a method of calculating the index of sustainable economic welfare. This index is the GDP per capita minus expenditure on the socio-economic and environmental factors:

$$ISEW = GDP – (SEC + EC), \qquad (6)$$

ISEW–index of sustainable economic welfare;
GDP – gross domestic (regional) product per capita;
SEC – socio-economic charges;
EC – environmental charges.

When calculate index of sustainable economic welfare as part of environmental costs are taken into account such variables as the cost of pollution of water, air, noise pollution, loss of agricultural land, compensation to future generations for loss of non-renewable sources. Thus, it can be noted that developers of the methodology have attempted to define environmental variables in monetary units, what is its advantage and disadvantage.

Point of the second approach to assessing the sustainability of development process consists in calculation of system of indexes, each of which reflects only one side of sustainable development: economic, social, environmental. This approach is more common than the first.

Noteworthy is technique of sustainable development, developed by Ukrainian scientists educational and scientific complex "Institute for applied system analysis" (ESC "IASA") of NTUU "KPI" NAS of Ukraine and MES of Ukraine, offered during stability analysis to combine three pillars of sustainable development: economic, environmental and social. Relationship of these components gives possibility to ensure a balanced development of socio-economic-ecological system of region.

Fundamental assignment in embodying concept of sustainable development is formation of standard for measures (indexes and indicators), reasonable quantitative and qualitative assessments of this very complicated process. Main requirements of specified measures (gauging matrix) are their information "completeness" and adequate representation of the interconnected triad of sustainable development components. Well known international organizations and numerous scientists are working in this direction, but unequivocal coordination of these efforts has not been yet achieved.

To meet this concept it is necessary to introduce a gauging matrix of sustainable development. Following sustainable development gauging matrix (SDGM) is proposed by the Institute for Applied System Analysis of the National Academy of Science of Ukraine and Ministry of Education and Science of Ukraine.

According to SDGM sustainable development is measured through appropriate I_{sd} index in space of three dimensions: economic (I_{ec}), ecological (I_e) and social (I_s) (Fig. 1). I_{sd} is a vector, whose norm determines the level of sustainable development and its orientation in a coordinate system (I_{ec}, I_e, I_s) characterizes "harmony" of development (harmonization degree – G).
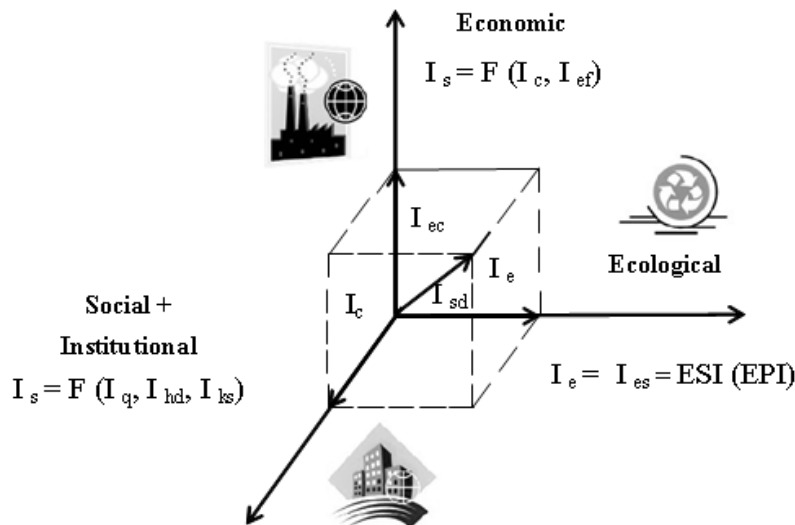

Fig. 1. Dimensions of sustainable development [13]

Thus, life quality component of sustainable development (I_{sd}) and the harmonization level of sustainable development (G) are calculated on the basis of their constituents (I_{ec}, I_e, I_s). This index is determined by three dimensions: economic (I_{ec}), ecological (I_e) and social (I_s). Respectively, each of indexes (I_{ec}, I_e, I_s) is calculated by six global indexes widely used in international practice (Tabl. 1).

Table 1

Set of global indexes used for calculation I_{sd} and G [13]

Sustainable development dimension	Global index	Constituents (49 indicators, 188 datasets)
I_{ec}	I_c – Growth (Global) Competitiveness Index	3 indicators, 47 sets of data
	I_{ec} – Economic freedom index	10 indicators, 50 sets of data
I_e	ESI (EPI) – Environmental Sustainablity (Performance) Index	21 indicators, 76 sets of data
I_s	I_q – Quality-of-life index	9 indicators
	I_{hd} – Human development index	3 indicators
	I_{ks} – Knowledge society index	3 indicators, 15 sets of data

Index of economic dimension (I_{ec}) shall be generated from two global indexes:

1. Growth (Global) Competitiveness Index (further – an index of competitiveness – I_c), which was developed by organizers of World Economic Forum. This index is annually defined for 125 economies of world and published in form named "the Global Competitiveness Report". Report for 2014–2015 [8], was used for this paper.Index of competitiveness is comprised of three such indicators: indicator of technological development of country; indicator of civil institutes and indicator for macroeconomic environment. In turn, these three indicators are calculated on the basis of 47 data sets including conditions for technologies transfers and innovational potential of country, level of development in information and communication technologies, level of investment for research and development, level of foreign direct investments, level of government non-interference in business, level of a country's perceived corruption, and others.

2. Economic Freedom Index (I_{ef}), developed by intellectual center of the Heritage Foundation [9]. It is printed annually in the Wall Street Journal. Economic Freedom Index is formed with following 10 indicators: trade policy of country, fiscal load on the part of government, governmental intervention in economy, monetary policy, streams of capital and foreign investment, banking and financial activity, policy of shaping prices and payments, right to private property, a policy of regulation, and informal activity of the market. These 10 indicators are composed using 50 sets of economic, financial, legislative and administrative data.

Index of ecological dimension (I_e) is generated on basis of well known Environmental Sustainability Index (ESI) designed by the Center of Ecological Legislation and Policy of Yale University (USA) for 146 countries of the world [10]. ESI is generated from 21 ecological indicators which, inturn, are defined by the use of 76 sets of ecological data, level of environmental pollution in past and presently,efforts of a country in management of its ecologicalconditions, ability of country to improve ecological itscharacteristics and others.

ESI quantitatively defines ability of any country to protect environment both currently, and inlong-term, emerging from five criteria: availability of national ecological system; ability to counteract ecological influences; reduction of people's dependence on ecological influences; social capabilities of country to meetecological challenges; possibility to exercise global control over ecological condition of country. Additionally, this index may be used as a powerful tool for decisionmaking at analytical level with allowance for socialand economic measurements of sustainable development ina country.

An index of social dimension (I_s) is generated by averaging three global indexes: 1. Quality of Life Index (I_q), is developed by international organization, Economist Intelligence Unit[11]. This index is formed with help of following nine indicators: the gross nationalproduct per capita calculated by parity of purchasingcapacity; average life expectancy of population incountry; rating for political stability and safety incountry; quantity of divorced families per 1000/population; level of public activism (the activity of tradeunions, public organizations etc.); distinctions betweengeographical divide given warmer and colder regions of country; rate of unemployment in country; level ofpolitical and civil freedom incountry; ratio of averagesalary of men compared to women; 2. Human Development Index (I_{hd}) which is used by the United Nations Development Program [12]. It is formed on basisof following three indicators: average life expectancy of the population of a country; level of education; standard of life, of population in country which is measured by gross national product per capita calculated by parity of purchasing capacity.

3. Index of Knowledge Societies, or K – societies (I_{ks}),was developed by department of the United Nations onEconomic and Social affairs – UNDESA [12]. This index is defined by three basicindicators: assets indicator;advancement indicatorand foresightedness indicator, which in turn, are formedwith help of 15 data sets on a level ofinvolvement ofyouth in education and information, investment climatein a country, the level of corruption, the inequality of distribution of material and social benefits (GINI-index), level of children's mortality rate, etc.

As seen in Table 1, sustainable development index (I_{sd}) and its harmonization degree (G) are defined in terms of 49 indicators and 188 datasets. On basis of composition for different indicatorsand data sets about these three dimensions, mathematicalmodel as a system of linear algebraic equations (Fig. 2)was developed for calculation of sustainable development index (I_{sd}).

All data, indicators and indexes which are includedin the model (Fig. 2) are measured in different units andhave various interpretations. This is why they are reducedto normal form in such way that their changes andchanges of their indexes themselves were in range from 0to 1. In this case the lowest values of above indicatorswill correspond to numerical values close to 0, and thehighest – will approximate these values to 1. Such normalization allows one to calculate each of indexes I_{ec}, I_e, I_s and I_{sd} in form of averaged sum of its constituentswith corresponding weighted coefficients. In turn,weighted coefficients in the calculation formula of sustainable development index (I_{sd}) are chosen in such a waythat allows one to provide the same weights of economic,ecological and social measures in this index.

Harmonization degree of sustainable development is angle between vector with the norm:

$$\|I_{sd}\| = \sqrt{I_{ec}^2 + I_e^2 + I_s^2}, \tag{7}$$

and an «ideal» vector, which is equidistant from each of coordinates (I_{ec}, I_e, I_s) withthe norm (Fig. 3)

$$\|I_i\| = \sqrt{1^2 + 1^2 + 1^2}, \tag{8}$$

This angle is measured in degrees in the following way:

$$\alpha = \arccos\left(\frac{I_{ec} + I_e + I_s}{\sqrt{3}\sqrt{I_{ec}^2 + I_e^2 + I_s^2}}\right), \tag{9}$$

and changes in limits:

$$0 \le \alpha \le \alpha_{max} ; \ \alpha_{max} = \arccos\left(\frac{1}{\sqrt{3}}\right), \tag{10}$$
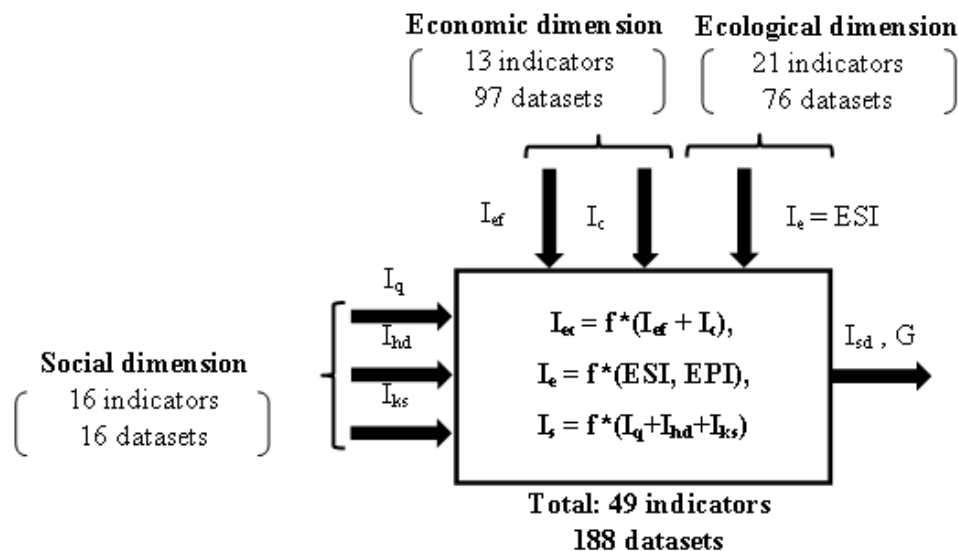
Fig. 2. Mathematical model for calculation of sustainable development index [13]
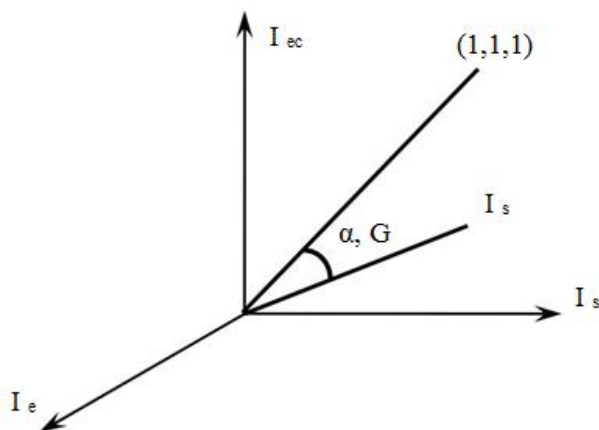

Fig. 3. Harmonization degree of sustainable development [13]

With approach of angle to 0, harmonization degree of sustainable development will increase. For ease of comparison, bring this indicator to normalized kind:

$$G = \frac{G' - G_{min}}{G_{max} - G_{min}},$$

where $G' = 1 - \frac{\alpha}{\alpha_{max}}$, $G_{max} = 1 - \frac{\alpha_1}{\alpha_{max}}$, $G_{min} = 1 - \frac{\alpha_2}{\alpha_{max}}$, $\alpha_1 = 0; \alpha_2 = \frac{45}{\pi} \arccos\left(\frac{1}{\sqrt{3}}\right)$;

As a result of this normalization of harmonization degree (G) will vary in range [0...0.75] and rise with approach of G to 1 and decrease with approximation to 0.75.

Conclusions: Indicators of sustainable development of region or country are key indicators of economic, social and environmental status of region, reflecting trends of its development and influence of various factors on persistence. They play a significant role in selection and formation of development strategy and evaluate its implementation. Therefore, the most important property of indicators of sustainable development should be their scientific validity.

Usage of indicators, with quantitative assessment can give possibility to make informed decisions: identify gaps in process of environmental management and to prevent them in the future, to interpret changes in socio-ecological-economic systems, to provide access to information for various categories of consumers, to improve exchange of scientific and technical information, to attract public attention to certain environmental threats.

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The usage of indicators, with quantitative assessment, can give possibility to make informed decisions: to identify gaps in the process of environmental management and to prevent them in future, to interpret changes in socio-ecological-economic systems, to provide access to information for various categories of consumers, to improve exchange of scientific and technical information, to attract public attention to certain environmental threats.

Keywords: sustainable development indicators, strategy, environmental policy, economic and social development.