9th International Scientific Conference
"Business and Management 2016"
May 12–13, 2016, Vilnius, LITHUANIA
http://www.bm.vgtu.lt

eISSN 2029-929X
eISBN 978-609-457-921-9
Article ID: bm.2016.60
http://dx.doi.org/10.3846/bm.2016.60

COMPLEX ASSESSMENT OF THE ECOLOGICAL DEVELOPMENT OF THE COUNTRY'S REGIONS

Romualdas Ginevičius[1], Andrius Stasiukynas[2], Dainora Gedvilaitė[3]

Department of Economics and Management of Enterprises, Business Management Faculty, Vilnius Gediminas Technical University, Saulėtekio al. 11, LT-10223 Vilnius, Lithuania
E-mails: [1]romualdas.ginevicius@vgtu.lt; [2]andrius.stasiukynas@vgtu.lt; [3]dainora.gedvilaite@vgtu.lt (corresponding author)

Abstract. Ecological development is one of the three components of sustainable development. To be able to analyse the impact of economic and social development on the ecological situation of the region, ecological development has to be assessed using quantitative methods. The ecological development of a region can be seen as a complex integrated phenomenon observed in many aspects. After formalizing them, i. e. converting them into criteria, we can form a system that upon applying multi-criteria methods will allow us to carry out a complex assessment of the ecological development of a region. The objective of this article is to provide methods for the quantitative assessment of the ecological state of a country's regions. Review of scientific literature, analysis of statistical data and the methods applied in the theory multiple criteria have been used for the research.

Keywords: sustainable development of regions, ecological development, multi-criteria methods, ecological development indicators, ecological development assessment, system of indicators.

JEL Classification: Q01; Q56.

1. Introduction

Today the development of any socioeconomic system is understood as sustainable development. The following concept of sustainable development has been formed in global environmental and economic development forums, which has become the classic concept: it is development that meets the current needs of society without compromising the ability of future generations to meet their own needs. Thus sustainable development is a compromise between the environmental, economic and social objectives of societies.

Sustainable development is especially relevant to regional politics, the aims of which are to reduce differences in the standard of life between different continents, countries, or regions of a country. The result of inefficient policies is the increase of social tension manifested by the extent of emigration, criminality, death rate, lower birth rate, etc.

One of the results of the unsustainable development of a country's regions is a deteriorating ecological situation due to the ineffective use of available resources, increased pollution, deforestation, etc.

Of the remaining two components of sustainable development – social and economic development – the latter has the biggest impact on ecology, as it covers industry, construction, transport, and agriculture. Studies of this issue carried out in different regions of the world clearly show the negative impact of economic development on the environment (Pope *et al.* 2004; Munitlak *et al.* 2009; Golusin, Munitlak 2009; Lapinskienė *et al.* 2014, 2015). To analyse the impact of economic development on ecological development, we need to express both of these components of sustainable development in a quantitative way.

Both the economic and ecological development of a region are attributed to complex integrated phenomena which manifest as many aspects in reality. Upon formalizing these aspects we obtain a system of indicators defining the analysed phenomenon. Where it consists of many indicators, a hierarchic system of indicators is formed (Ginevičius *et al.* 2014; Ginevičius 2009). This allows reducing the number of indicators assessed at one time by determining their weight by employing the expert method.

After carrying out a multi-criteria assessment of such a system of indicators, depending on the assessed objective, it is possible to determine the state of economic or ecological development of an individual region or to rank regions according to the degree of development.

The objective of this article is to provide methods for the quantitative assessment of the ecological state of a country's regions and verify such methods against the regions of Lithuania.

2. Assessment of the ecological development state of a country's regions

Two essential aspects of the analysis of ecological development can be distinguished. First of all, the formation of a system of indicators that reflect it; second, the way or method of the quantitative assessment of the state of ecological development.

All authors analysing ecological development unanimously agree that it is a complex integrated phenomenon manifested by many aspects in reality. In order to carry out a quantitative assessment of ecological state, these aspects are formalized and converted into indicators.

Opinions concerning the composition of indicators differ. Today the situation is such that it is attempted to provide as many indicators reflecting ecological development as possible, but practical calculations use only a small number of such indicators (Atkisson, Hatcher 2001; Golusin *et al.* 2011; Boggia, Cortina 2010; Munitlak *et al.* 2009; Babu, Datta 2015; Wallis *et al.* 2011). This is due to several reasons. First, it is taken into account which indicators were used in previous studies; second, the availability of data about these indicators; third, the accuracy of such data (Golusin *et al.* 2011). In most cases it is based on indicators for which official data is available.

One more aspect of the analysis of ecological development has to be stressed – the object of most studies are either individual continents and the countries thereon or the countries of a continent, or the annual dynamics of the state of ecological development in individual countries (Wong 2002; Munitlak *et al.* 2009; Golusin, Munitlak 2009; Ferrarini *et al.* 2001). Very few studies concentrate on the ecological development of a country's regions (Wallis *et al.* 2011; Giddings *et al.* 2002).

Their number in the suggested systems of ecological development indicators is different and varies from several to several dozens. For example, the study of the Southeast region of Europe is based on a system of ten indicators (Golusin *et al.* 2011), another study is based on nine indicators (Boggia, Cortina 2010), systems of four (Kondyli 2010; Čiegis *et al.* 2010) and seven indicators (Babu, Datta 2015; Wallis *et al.* 2011), etc. are also suggested.

A more detailed analysis showed that indicators are often selected by way of decomposition. This compounds the calculations and reduces accuracy. Especially since such indicators often reflect one and the same – a rather homogenous aspect, for example, certain pollutants expelled by certain sources. Therefore we believe that ecological development can be rather adequately reflected by a rather limited number of essential indicators. In such a case, the possibility to obtain information on those indicators increases.

Another important moment when forming a system of indicators is the possibility to obtain data about such indicators in the required cross-section. The object of our study is the ecological development of a country's region and its calculation on the basis of the regions of Lithuania, thus we based the study on information about their ecological development provided by Statistics Lithuania (2011, 2012, 2013). The following indicators were provided (Counties of Lithuania 2010, 2011, 2012):

- Collected and consumed water (thou. m^3);
- Released waste water (thou. m^3).
- Pollutants expelled from stationary sources of pollution (t).
- Area of forests compared to the area of the region (percentage).

In this case the system of indicators of the ecological development of the regions of Lithuania is shown in Figure 1.

As you can see, all indicators of ecological development are converted into relative indicators to assess adequately the ecological development of the country's regions.

The values of ecological development indicators of the regions of Lithuania for 2010–2012 are provided in Table 1.

Literature analysis on the quantitative assessment of the state of ecological development showed that mostly multi-criteria methods are employed (Boggia, Cortina 2010; Krajnc, Glavic 2005; Kevin 2007; Ferrarini *et al.* 2001; Zhou *et al.* 2007). In such a case it is attempted to consolidate ecological development indicators expressed in different dimensions with a different impact on this development into one aggregate value.

Two models of such aggregation are distinguished. The first can be shown in this way (Golusin *et al.* 2011):

$$Ej = \sum_{i=1}^{l} w_i^+ \tilde{q}_i^+ - \sum_{i=1}^{n} w_i^- \tilde{q}_i^- , \qquad (1)$$

where E_j – the value of the quantitative assessment of the state of ecological development of an analysed phenomenon j (region, country, country's region, etc.); w_i^+ – the weight of factor i improving the ecological situation; w_i^- – the weight of factor i aggravating the ecological situation; $\tilde{q}_i^+$ – the normalized value of factor i improving the ecological situation; $\tilde{q}_i^-$ – the normalized value of factor i aggravating the ecological situation.

Thus in this case (1) the nature of the change of factors in the formula is not changed, i.e. it includes both maximizing and minimizing factors.

The quantitative assessment of the state of ecological development may also be done by applying a multi-criteria model based on the SAW (Simple Additive Weighting) method (Hwang, Yoon 1981):

$$E_j^{SAW} = \sum_{i=1}^{n} w_i \tilde{q}_i , \qquad (2)$$

where: E_j^{SAW} – the value of the quantitative assessment applying the SAW method of the state of ecological development of an analysed phenomenon j (region, country, country's region, etc.); w_i – the weight of indicator i; $\tilde{q}_i$ – the normalized value of indicator i.

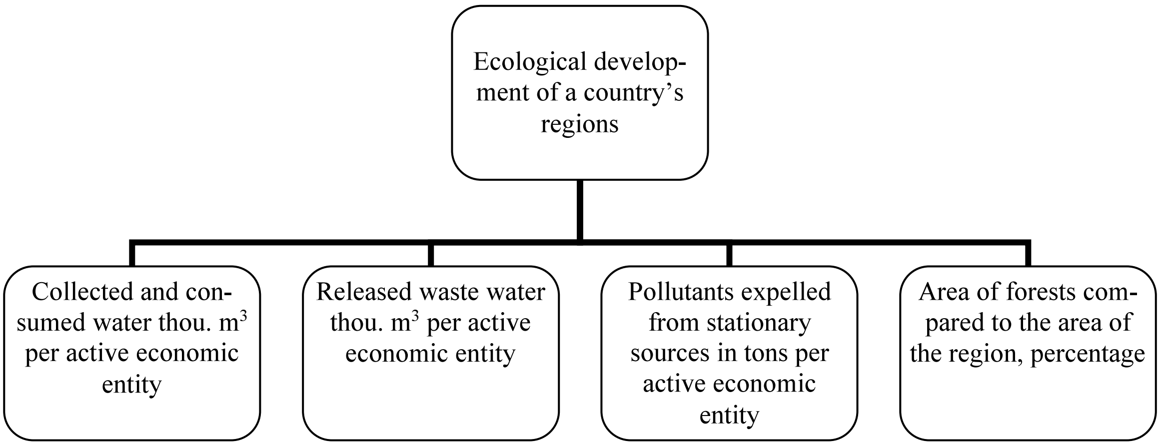

Fig. 1. System of indicators of the ecological development of the regions of Lithuania
(Source: compiled by the authors)

Table 1. Values of ecological development indicators of the regions of Lithuania for 2010–2012
(Source: Statistics Lithuania 2011, 2012, 2013)

Name of the region	Name of ecological development indicators											
	Collected and consumed water (thou. m^3)			Released waste water (thou. m^3)			Pollutants expelled from stationary sources of pollution (tons)			Area of forests compared to the area of the region (percentage)		
	2010	2011	2012	2010	2011	2012	2010	2011	2012	2010	2011	2012
Vilnius	910574.2	653699.8	806213	461662.2	332406.2	410880.1	7289.8	7117.4	6818.8	0.43695	0.44003	0.43900
Kaunas	6412204	4956064	4699623	3202221	2472541	2337299	10477.4	11118.1	10909.7	0.29595	0.29595	0.29694
Klaipėda	48132	45357.9	48284	34164	34488.2	34760.7	5786.4	4842.9	4902.6	0.26396	0.26396	0.26396
Alytus	20382.3	20812.8	19711.7	10267.5	9863.6	8985.9	1322.9	1288.1	1438.1	0.49106	0.49106	0.48995
Marijampolė	19467.1	19932.7	22513.2	12340.8	12390.1	13403	1929.7	2238.5	2057.1	0.21689	0.21689	0.2168
Panevėžys	23994.2	23626.2	23774.3	16395	15305.4	16755.4	2788.7	2936.1	3360.7	028194	0.28194	0.2819
Šiauliai	23240	23254	23167	18415	18677	2938538	5199.5	7395.3	7227.1	0.32400	0.32400	0.3240
Telšiai	19059	19369.5	20237	11990	14109	14022	26420	28080.5	25411.3	0.36092	0.36092	0.3609
Utena	209150.8	2055244	158060	103692.2	103524	80071.6	1951.4	1667.1	1861.2	0.34106	0.34106	0.3410
Tauragė	5752	5422.4	5379	3488	4119	3988	712.5	833.3	877.5	0.33008	033008	0.3300

The SAW method (Hwang, Yoon 1981) is used in the reaearch.

Table 1 distinguishes two circumstances which need to be evaluated, first, the nature of ecological development indicators is different: the first three are minimizing, while the fourth is maximizing. This means that the growing values of the first three indicators signal a deterioration of the ecological situation, and the increase of the value of the fourth indicator signals an improvement of the situation. The multi-criteria assessment SAW method requires the nature of change of all indicators to be the same, i.e. all of them need to be maximizing or minimizing.

Maximization of the values of indicators is performed in the following way (Hwang, Yoon 1981):

$$q_i^{\max} = \frac{q_{i\min}}{q_i}, \tag{3}$$

where: $q_i^{\max}$ – the maximized value of indicator i; q_i – the value of indicator i; $q_{i\min}$ – the lowest value of indicator i for all regions.

Minimization of values of indicators is done in the following way (Hwang, Yoon 1981):

$$q_i^{\min} = \frac{q_i}{q_{i\max}}, \tag{4}$$

where: $q_i^{\min}$ – the minimized value of indicator i; $q_{i\max}$ – the highest possible value of indicator i for all regions.

Similarly to the perspective in the first case, the second aspect is that ecological development indicators are expressed in different dimensions, i.e. they are incomparable. The values need to be normalized to become comparable. The method of normalization depends on the objective of multi-criteria assessment. If we want to rank the regions of the country according to the degree of ecological development, normalization is performed in the following way (Ginevičius, Podvezko 2004, 2007; Ginevičius *et al.* 2006):

$$\tilde{q}_i = \frac{q_i}{\sum_{i=1}^{n} q_i}, \tag{5}$$

where: $\tilde{q}_i$ – the normalized value of indicator i ($i = 1,\overline{n}$, n – number of indicators).

In the event that we want to use the results of integrated ecological development assessment of regions for further research, for example the analysis of the impact of economic development, then this method of the normalization of values of indicators is not suitable. This is due to the fact that seeking the comparability of regions the normalized value of indicator i taken individually results from the general context, i.e. this value is influenced by the values of this indicator of all other regions.

We need to determine the state of ecological development of an individual region of a country, therefore we should perform normalization employing the ESP method (Ginevičius *et al.* 2012, 2015; Ginevičius 2008):

$$\tilde{\tilde{q}}_i = \frac{q_i}{q_{i\max}}, \tag{6}$$

where: $\tilde{\tilde{q}}_i$ – the normalized value of indicator i; $q_{i\max}$ – the highest value of indicator i (obtained from statistical data or established through expert assessment).

In this case the value of indicator $\tilde{\tilde{q}}_i$ for the analysed region does not depend on the values of the same indicators of other regions.

Based on Table 1 and formula (4) the maximization of the values of ecological development of regions was performed. The results are presented in Table 2.

The next phase of multi-criteria assessment is the normalization of indicator values, i.e. their conversion into non-dimensional comparable values. Based on Table 2 and formula (5) the following results were obtained (Table 3).

The weights of ecological development indicators of the regions were determined by interviewing experts. After the verification of the compatibility of their opinions using the Pearson criteria χ^2, the following values were obtained (Table 4).

After obtaining normalized indicator values and weights of the indicators, we can continue to the quantitative integrated assessment of the ecological development of the regions of Lithuania. This is performed using the SAW method (Hwang, Yoon 1981). In one case we ranked the regions according to ecological development (Table 5), and in the other case we determined the state of ecological development of every region (Table 6).

The ranking of the regions of the country according to ecological development (Table 5) can be used as a basis for formulating the measures of regional development intended to reduce differences between regions. This can be done by respectively directing the domestic investment of the country.

Table 2. Maximized values of ecological development indicators of the regions of Lithuania (Source: compiled by the authors)

Name of the region	Name of ecological development indicators											
	Collected and consumed water (thou. m^3) per active economic entity			Released waste water (thou. m^3) per active economic entity			Pollutants expelled from stationary sources of pollution (tons) per active economic entity			Area of forests compared to the area of the region (percentage)		
	2010	2011	2012	2010	2011	2012	2010	2011	2012	2010	2011	2012
Vilnius	0.09395	0.12323	0.10230	0.11238	0.18409	0.14883	1	1	1	0.43695	0.44003	0.43900
Kaunas	0.00765	0.00929	0.00999	0.0093	0.01415	0.01490	0.39938	0.36602	0.35604	0.29595	0.29595	0.29694
Klaipėda	0.62105	0.607797	0.570431	0.530608	0.60721	0.58745	0.440187	0.50293	0.46443	0.26396	0.26396	0.26396
Alytus	0.44769	0.421312	0.443854	0.538926	0.67530	0.721865	0.587718	0.60144	0.50294	0.49106	0.49106	0.48995
Marijam-polė	0.44388	0.395295	0.352173	0.424604	0.48307	0.438576	0.38154	0.31098	0.31862	0.21689	0.21689	0.21689
Panevėžys	0.72318	0.677925	0.660289	0.641802	0.79493	0.694609	0.530167	0.48196	0.38615	0.28194	0.28194	0.28194
Šiauliai	0.83609	0.785571	0.799612	0.639849	0.74297	0.004674	0.318413	0.21824	0.2119	0.32400	0.32400	0.32400
Telšiai	0.49866	0.447319	0.434231	0.480671	0.46648	0.464633	0.03065	0.02726	0.02858	0.36092	0.36092	0.36092
Utena	0.03918	0.037322	0.046932	0.047925	0.05628	0.068686	0.357822	0.40651	0.32949	0.34106	0.34106	0.34106
Tauragė	1	1	1	1	1	1	0.687851	0.57490	0.50675	0.33008	0.33008	0.33008

Table 3. Normalized values of ecological development indicators of the regions of the country for 2010–2012 (Source: compiled by the authors)

Name of the region	Name of ecological development indicators											
	Collected and consumed water (thou. m^3) per active economic entity			Released waste water (thou. m^3) per active economic entity			Pollutants expelled from stationary sources of pollution (tons) per active economic entity			Area of forests compared to the area of the region (percentage)		
	2010	2011	2012	2010	2011	2012	2010	2011	2012	2010	2011	2012
Vilnius	0.09395	0.12323	0.10230	0.11238	0.18409	0.14883	1	1	1	0.88981	0.89609	0.89602
Kaunas	0.00765	0.00929	0.00999	0.0093	0.01415	0.01490	0.39938	0.36602	0.35604	0.60269	0.60269	0.60607
Klaipėda	0.62108	0.60779	0.57043	0.53060	0.60721	0.58745	0.44018	0.50293	0.46443	0.53754	0.53754	0.53875
Alytus	0.44769	0.42131	0.44385	0.53892	0.67530	0.72186	0.58771	0.60144	0.50294	1	1	1
Marijam-polė	0.44388	0.39529	0.35217	0.42460	0.48307	0.43857	0.38154	0.31098	0.31862	0.44168	0.44168	0.44268
Panevėžys	0.72318	0.67792	0.66028	0.64180	0.79493	0.69460	0.53016	0.48196	0.38615	0.57415	0.57415	0.57545
Šiauliai	0.83609	0.78557	0.79961	0.63984	0.74297	0.00467	0.31841	0.21824	0.2119	0.65980	0.65980	0.66129
Telšiai	0.49866	0.44731	0.43423	0.48067	0.46648	0.46463	0.03065	0.02726	0.02858	0.73498	0.73498	0.73664
Utena	0.03918	0.03732	0.04693	0.04792	0.05628	0.06868	0.35782	0.40651	0.32949	0.69454	0.69454	0.69611
Tauragė	1	1	1	1	1	1	0.68785	0.574909	0.506757	0.672187	0.72187	0.673704

Table 4. Weights of ecological development indicators of the regions of Lithuania (Source: compiled by the authors)

Name of the indicator	Collected and consumed water (thou. m^3) per active economic entity	Released waste water (thou. m^3) per active economic entity	Pollutants expelled from stationary sources of pollution (tons) per active economic entity	Area of forests compared to the area of the region (percentage)	Total
Weight of the indicator	0.25	0.15	0.5	0.1	1.0

Table 5. Regions of Lithuania ranked according to their ecological development
(Source: compiled by the authors)

No.	Regions	2010		2011		2012	
		Value	Rank	Value	Rank	Value	Rank
1.	Vilnius	0.12749	2	0.136838	2	0.146103	2
2.	Kaunas	0.05176	9	0.050541	10	0.053351	10
3.	Klaipėda	0.10533	6	0.115748	5	0.11799	4
4.	Alytus	0.118788	4	0.125188	3	0.127143	3
5.	Marijampolė	0.084732	7	0.077469	7	0.081089	6
6.	Panevėžys	0.124558	3	0.123446	4	0.117954	5
7.	Šiauliai	0.109375	5	0.099759	6	0.080895	7
8.	Telšiai	0.056785	8	0.052572	9	0.055652	8
9.	Utena	0.051701	10	0.059211	8	0.055471	9
10.	Tauragė	0.169481	1	0.159229	1	0.164352	1

Table 6. Results of multi-criteria assessment of ecological development of the regions of Lithuania
(Source: compiled by the authors)

No.	Regions	2010		2011		2012	
		Value	Rank	Value	Rank	Value	Rank
1.	Vilnius	0.629329	2	0.648033	2	0.637504	2
2.	Kaunas	0.263273	10	0.247726	10	0.243366	10
3.	Klaipėda	0.50871	6	0.548255	5	0.516819	5
4.	Alytus	0.586622	4	0.607345	3	0.570716	3
5.	Marijampolė	0.4096	7	0.370946	7	0.357412	7
6.	Panevėžys	0.599565	3	0.587119	4	0.519884	4
7.	Šiauliai	0.530188	5	0.482941	6	0.372684	6
8.	Telšiai	0.28559	8	0.268932	9	0.266211	8
9.	Utena	0.26535	9	0.290487	8	0.256393	9
10.	Tauragė	0.811144	1	0.754673	1	0.720749	1

Data about the ecological development of an individual region (Table 6) can be used, for instance, for the correlation-regression analysis of the impact of economic development on ecology.

3. Conclusions

In order to carry out the quantitative assessment of the state of the ecological development of a region of the country, first we need to solve two problems. First of all to form a system of indicators; secondly, to determine the method of aggregating such indicators into one cumulative value.

Different systems of indicators have been suggested. They differ both in the number of indicators and their composition. In many instances their structure is determined by three circumstances: first, the indicators used in previous studies; second, the availability of data about such indicators; third, the accuracy of the data. On the other hand, systems of indicators are often too detailed, which encumbers calculations and reduces accuracy, therefore the system should only include essential indicators that contain related indicators of a lower level.

There are two methods of aggregating ecological development indicators expressed by different dimensions and operating in different directions into one cumulative value. First, where the nature of the change of factors is not changed, i.e. they remain maximizing or minimizing. Second, where through transformation all the factors become maximizing or minimizing and only then are aggregated into one cumulative value. Further research will show which of the methods is more accurate.

References

Atkisson, A.; Hatcher, R. 2001. The compass index of sustainability: prototype for a comprehensive sustainability information system, *Journal of Environmental Assessment Policy and Management* 3(4): 509–532.

Babu, S.; Datta, S. K. 2015. Revisiting the link between socio-economic development and environmental status indicators – focus on panel data, *Environment, Development and Sustainability* 17(3): 567–586. http://dx.doi.org/10.1007/s10668-014-9561-6

Boggia, A.; Cortina, C. 2010. Measuring sustainable development using a multi-criteria model: a case study, *Journal of Environmental Management* 91: 2301–2306. http://dx.doi.org/10.1016/j.jenvman.2010.06.009

Čiegis, R.; Ramanauskienė, J.; Šimanskienė, L. 2010. *Lietuvos regionų darnaus vystymosi vertinimas* [Evaluation of sustainable development of Lithuanian regions]. Klaipėda: Klaipėdos universiteto leidykla (in Lithuanian).

Ferrarini, A.; Bodini, A.; Becchi, M. 2001. Environmental quality and sustainability in the province of Reggio Emilia (Italy): using multi-criteria analysis to assess and compare municipal performance, *Journal of Environmental Management* 63: 117–131. http://dx.doi.org/10.1006/jema.2001.0465

Giddings, B.; Hopwood, B.; O'Brien, G. 2002. Environment, economy and society: fitting them together into sustainable development, *Sustainable Development* 10: 187–196. http://dx.doi.org/10.1002/sd.199

Ginevičius, R. 2008. Normalization of quantities of various dimensions, *Journal of Business Economics and Management* 9(1): 79–86. http://dx.doi.org/10.3846/1611-1699.2008.9.79-86

Ginevičius, R. 2009. Socioekonominių sistemų būklės kiekybinio įvertinimo problematika [Some problems of quantitative evaluation of the state of social-economic systems], *Verslas: teorija ir praktika* 10(2): 69–83 (in Lithuanian). http://dx.doi.org/10.3846/1648-0627.2009.10.69-83

Ginevičius, R.; Butkevičius, A.; Podvezko, V. 2006. Complex evaluation of economic development of the Baltic States and Poland, *Ekonomický Časopis* 9(54): 918–930.

Ginevičius, R.; Gedvilaitė, D.; Bruzgė, Š. 2015. Assessment of a country's regional economic development on the basis of Estimation of a Single Process (ESP) method, *Entrepreneurial Business and Economics Review (EBER)* 3(2): 141–153. http://dx.doi.org/10.15678/EBER.2015.030210

Ginevičius, R.; Hogeforster, M.; Gedvilaitė, D. 2014. The formation of the system of indicators of development of the country's regions, in *8th International Scientific Conference "Business and Management 2014"*, 15–16 May 2014, Vilnius, Lithuania.

Ginevičius, R.; Podvezko, V. 2004. Complex evaluation of the use of information technologies in the countries of Easters and Central Europe, *Journal of Business Economics and Management* 5(4): 183–191.

Ginevičius, R.; Podvezko, V. 2007. Complex assessment of sustainable development of state regions with emphasis on ecological and dwelling conditions, *Ekologija* 53: 41–48.

Ginevičius, R.; Podvezko, V.; Podvezko, A. 2012. A new approach for evaluating of socio-economical processes by muti-criteria decision methods, in *7th International Scientific Conference "Business and Management 2012"*, 10–11 May 2012, Vilnius, Lithuania.

Golusin, M.; Munitlak, O. I. 2009. Definition, characteristics and state of the indicators of sustainable development in countries of Southeastern Europe, *Agriculture, Ecosystems and Environment* 130: 67–74. http://dx.doi.org/10.1016/j.agee.2008.11.018

Golusin, M.; Munitlak, O. I.; Teodorovic, N. 2011. The review of the achieved degree of sustainable development in South Eastern Europe – the use of linear regression method, *Renewable and Sustainable Energy Reviews* 15: 766–772. http://dx.doi.org/10.1016/j.rser.2010.07.064

Hwang, C. L.; Yoon, K. 1981. *Multiple attribute decision making–methods and applications. A state of the art survey.* Berlin, Heidelberg, New York: Springer Verlag.

Kevin, F. R. L. 2007. Evaluating environmental sustainability: an integration of multiple-criteria decision-making and fuzzy logic, *Environmental Management* 39: 721–736. http://dx.doi.org/10.1007/s00267-005-0395-8

Kondyli, J. 2010. Measurement and evaluation of sustainable development – a composite indicator for the islands of the North Aegean region, Greece, *Environmental Impact Assessment Review* 30: 347–356. http://dx.doi.org/10.1016/j.eiar.2009.08.006

Krajnc, D.; Glavic, P. 2005. A model for integrated assessment of sustainable development, *Resources, Conservation and Recycling* 43: 189–208. http://dx.doi.org/10.1016/S0921-3449(04)00120-X

Lapinskienė, G.; Tvaronavičienė, M.; Vaitkus, P. 2014. The emissions of greenhouse gases and economic growth – the evidence of the presence of the environmental Kuznets curve in the European Union countries, *Technological and Economic Development of Economy* 20(1): 65–78. http://dx.doi.org/10.3846/20294913.2014.881434

Lapinskienė, G.; Peleckis, K.; Radavičius, M. 2015. Economic development and greenhouse gas emissions in the EU countries, *Journal of Business Economics and Management* 16(6): 1131–1145. http://dx.doi.org/10.3846/16111699.2015.1112830

Munitlak, O. I.; Golusin, M.; Dodic, S.; Dodic, J. 2009. Perspectives of sustainable development in countries of Southeastern Europe, *Renewable and Sustainable Energy Reviews* 13(8): 2179–2187. http://dx.doi.org/10.1016/j.rser.2009.03.004

Pope, G.; Annandale, D.; Morrison-Saunders, A. 2004. Conceptualising sustainability assessment, *Environmental Impact Assessment Review* 24(6): 595–616. http://dx.doi.org/10.1016/j.eiar.2004.03.001

Statistics Lithuania. 2011. *Counties of Lithuania 2010* [online]. Vilnius [cited 10 February 2016]. Available from Internet: http://osp.stat.gov.lt/services-portlet/pub-edition-file?id=14761

Statistics Lithuania. 2012. *Counties of Lithuania 2011* [online]. Vilnius [cited 10 February 2016]. Available from Internet: http://osp.stat.gov.lt/services-portlet/pub-edition-file?id=2068

Statistics Lithuania. 2013. *Counties of Lithuania 2012* [online]. 2013. Vilnius [cited 10 February 2016]. Available from Internet: http://osp.stat.gov.lt/services-portlet/pub-edition-file?id=15047

Wallis, A. M.; Graymore, L. M.; Richards, A. J. 2011. Significance of environment in the assessment of sustainable development: the case for south west Victoria, *Ecological Economics* 70(4): 595–605. http://dx.doi.org/10.1016/j.ecolecon.2010.11.010

Wong, C. 2002. Developing indicators to inform local economic development in England, *Urban Studies* 39(10): 1833–1863. http://dx.doi.org/10.1080/0042098022000002984

Zhou, J.; Xiao, H.; Shang, J; Zhang, X. 2007. Assessment of sustainable development system in Suihua City, China, *Chinese Geographical Science* 17(4): 304–310. http://dx.doi.org/10.1007/s11769-007-0304-6