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## A comparative analysis of selected synthetic indicators of sustainability

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### Abstract

The problem of measuring the level of sustainable development is a current subject of numerous scientific studies. The need to monitor the level of sustainable development results from the strategy of the European Union, the aim of which is the pursuit of equal opportunities for all member countries. The literature review indicates numerous publications on methods and tools for measurement of the level of sustainable development based on quantitative methods, which enable the objectification of the conducted research and conclusions based on them. However, they require having reliable numerical information in all dimensions covered by the study. Multidimensionality of the sustainable development, which concerns the social sphere and the quality of life, the economic sphere and the environmental sphere entails numerous difficulties in the unambiguous, but at the same time its comprehensive measurement. In theory and practice there are many methods and tools concerning this issue, but so far each method has both advantages and disadvantages, therefore there is still no universal tool. Hence the scope of the article, which presents a review of selected synthetic measures used for assessing the level of sustainable development, with special consideration of the levels for Poland and the Czech Republic in the assessed areas of sustainable development. The research methodology can also be used in business practice for assessing the level of the sustainable development of corporations, industrial sectors or regions or cities.

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## 1. Introduction

The mankind constantly strives to increase the welfare of societies and to improve the quality of life, which results in increase of demand for raw materials and energy. With the end of the XVIII century the negative effects of the industrial revolution and the increasing pressure of the man on the Earth have been strongly highlighted. The human population is growing exponentially, while the number of available natural resources is limited. Hence the numerous initiatives and concepts of scientists, international organisations or global corporations aimed to minimise the human pressure on the natural environment taking into account aspects of the society development. The concept of the socio-economic development and environmental protection are interdependent, and in scientific publications they started functioning under the following names, e.g., ecological development (Sachs, 1979), development without destruction (Tolba, 1976) or environmentally-friendly development (David and Duckstein, 1976). In 1980 the International Union for Conservation of Nature – IUCN in cooperation with the World Wildlife Fund – WWF and the United Nations Development Programme – UNDP published a document entitled: “Global Strategy to Maintain Nature” (WCS, 1980). The report stressed the importance of social and environmental factors in the long-term socio-economic development. It has also become the base for the today most widely distributed notion in economics, respecting the natural environment – the concept of the so-called sustainable development. This notion, as the political and environmental model, was used for the first time in the Report of the World Commission on Environment and Development (WCED, 1987) entitled “Our Common Future”. The concept core is to preserve the regenerative capacity of the natural environment meeting the needs of the current generations, without limiting the possibilities of future generations to meet their needs. Starting from the above assumption, literature develops the diverse methodology of measurement of the consumption level of today generations and on the other hand, the regenerative possibilities of the natural environment. The problem of sustainable development has recently been gaining more and more importance in practice. Literature review shows number of ways in which the level of sustainable development can be measured and assessed in different approach and methodologies. The topic of monitoring and assessing sustainable development is frequently addressed in scientific publications, both on the national or regional scale (Bluszcz 2015, Giannias and Sfakianaki 2014; Hąbek 2014; Prochowicz and Sleszyński 2006), international scale (Stec et al. 2014; Hąbek and Wolniak 2013) as well as sector (Bluszcz and Kijewska 2015, Burchart-Korol et al., 2014; Weber 2008; Jenkins and Yakovleva 2006) – and company (Azapagic and Perdan 2000; Gajdzik 2012; Perrini and Tencati 2006; Hąbek and Wolniak 2015; Branco and Rodrigues 2007) -related scale. The article presented the selected synthetic measures, which enable the assessment of the sustainable development level, including among others: Sustainable Society Index (SSI), Environmental Performance Index (EPI), Ecological Footprint (EF) and Synthetic indicator of sustainable development (SISD). The comparative analysis was performed with special emphasis on Poland and the Czech Republic, which indicated the following similarities and differences in the studied areas.

## 2. Methodology and Data

Sustainable development as a complex and multidimensional problem needs developing some synthetic indicators that allow the assessment of the level of sustainable development. The method of aggregation of individual indices enabled measurement of the characteristics and phenomena that are expressed in various units or which have a qualitative character.

Measurement of the sustainable development level using the synthetic indicators has numerous advantages, which include, among others:

- the level of the synthetic indicators presented in a fairly long period enables keeping track of the basic changes occurring in the economy, the interpretation of the synthetic indicator and the inference on its basis are possible at the expert, political and general social level,
- recognition in the synthetic form, of the multidimensionality of the issue of sustainable development facilitates the comparative analysis in time and international space.

However, there are many opinions revealing the weaknesses of this approach, which among others include:

- a single number assessment can be treated as the ideal assessment of the level of sustainable development, but in reality in each synthetic metre we can indicate areas, which play a slightly bigger role, therefore their appropriate number and a commentary are important,
- a condition of a proper observation of long-term trends based on synthetic indicators requires collecting many reliable partial data, the same for all countries. However, in practice, there may occur different transformations of the national statistics or changes of basic categories, which can cause heterogeneity of the research material, and thus weaken the formal correctness of synthetic indicators.

Being aware of both, the strengths and weaknesses of synthetic indicators, the article presented selected indicators describing the level of sustainable development as significant in the assessment and comparative analysis of Poland and the Czech Republic. Each assessment and measurement provides a significant amount of information, which should constitute guidelines for further strategic actions for the sustainable development of member countries.

### 3. The results of measurement of sustainable development based on selected synthetic indicators

#### 3.1. Sustainable Society Index (SSI)

This indicator has been developed recently for a sustainable society which combines both aspects of sustainability and quality of life. The SSI is based on a solid definition of sustainability, the well-known and worldwide respected definition of the Brundtland Commission. To make explicitly clear that sustainability includes Human Well-being as well as Environmental Well-being the definition of sustainability has been extended with a third sentence, so it runs as follows: A sustainable society is a society that meets the needs of the present generation; that does not compromise the ability of future generations to meet their own needs; and in which each human being has the opportunity to develop itself in freedom, within a well-balanced society and in harmony with its surroundings (Van de Kerk and Manuel 2014). This index allows assessment the level of sustainability of a country and consists of 21 indicators (Table 1). The score of Poland and the Czech Republic is presented in Table 1, which contains the comparative analysis of the level of sustainable development of Poland and the Czech Republic according to 21 indicators included in the synthetic SSI index. SSI index includes three dimensions such as: human well-being; environmental well-being and economic well-being. In the human well-being dimension Poland and the Czech Republic obtained the same level of three indicators, i.e., sufficient food, sufficient to drink (obtaining the maximal values of indicators at the level of 10) and governance obtaining the same assessment of 6,7. According to the three indicators, Poland obtained higher grades than the Czech Republic, i.e.: education, gender equality and population growth. While Poland has been assessed lower, than the Czech Republic in terms of safe sanitation, healthy life and income distribution and in the environmental well-being dimension. Poland obtained a higher grade than the Czech Republic in terms of the following indicators: biodiversity, energy use, greenhouse gases. While lower levels of indicators were obtained by Poland in comparison to the Czech Republic in terms of renewable water resources; consumption of renewable energy and energy savings. In the economic well-being dimension Poland only in terms of genuine savings has reached a higher level than the Czech Republic. While in terms of other four indicators it has been assessed lower, i.e., due to: organic farming, gross domestic product, employment, public debt, what has been presented in fig. 1.

Table 1. The values of SSI index of Poland and The Czech Republic.

Dimensions	Categories	Indicators	Poland	The Czech Republic	Difference
Human Well-being	Basic Needs	Sufficient Food	10	10	0
		Sufficient to Drink	10	10	0
		Safe Sanitation	9	10	-1
	Health	Education	9	8,8	0,2
		Healthy Life	8,1	8,5	-0,4
		Gender Equality	7	6,8	0,2

Personal and Social Development	Income Distribution	6,6	8,8	-2,2
	Population Growth	7,5	7,1	0,4
	Good Governance	6,7	6,7	0
Environmental Well-being	Biodiversity	8,8	7,5	1,3
	Renewable Water Resources	8,1	8,7	-0,6
	Consumption	2,7	3	-0,3
	Energy Use	4,9	1,9	3
	Energy Savings	5,3	6,5	-1,2
	Greenhouse Gases	2,4	1	1,4
	Renewable Energy	1	1	0
Economic Well-being	Organic Farming	6,6	9,4	-2,8
	Genuine Savings	8,2	7,5	0,7
	Gross Domestic Product	7,8	8,6	-0,8
	Employment	3,6	5	-1,4
	Public Debt	5,6	7,5	-1,9

Source: based on Van de Kerk and Manuel (2014) and <http://www.ssindex.com/interactive-maps/>

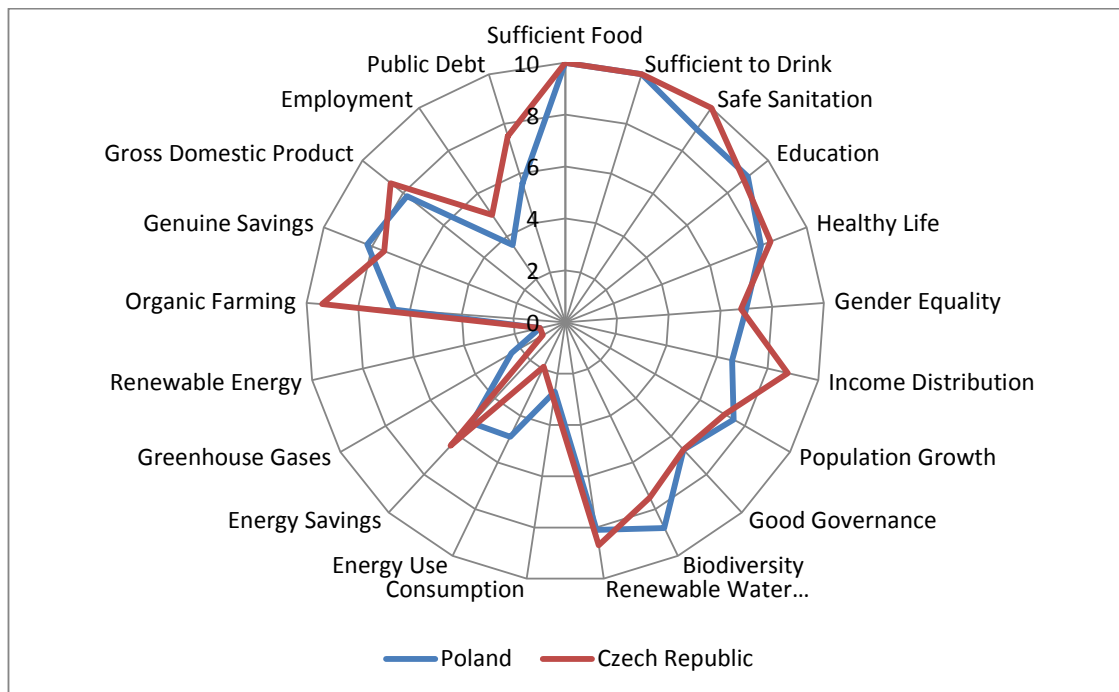


Fig. 1. Position of Poland and the Czech Republic according to SSI  
 Source: own based on data from: <http://www.ssindex.com/interactive-maps/>

The chart shows the scores for each of the 21 indicators for Poland. The outer circle represents full sustainability, the centre of the chart means no sustainability at all. In summary, according to all assessed 21 indicators, Poland

obtained lower grades than the Czech Republic for eleven indicators; the level of four indicators was the same, while in terms of seven of them Poland has been assessed higher.

The differences presented in table 1 and in figure 1 are directly reflected in the ranking of 151 countries included in the study according to SSI presented in table 2, from which it results that the Czech Republic in 2014 in the human well-being dimension achieved a higher position than Poland, i.e., the 11<sup>th</sup> place, and Poland took the 29<sup>th</sup> place. In the assessment of the environmental well-being dimension, Poland took the place higher than the Czech Republic, i.e., the 110<sup>th</sup> place, while the Czech Republic was on a distant 129<sup>th</sup> location. In terms of the economic well-being dimension, the Czech Republic was at a high 8<sup>th</sup> position, while Poland took the 19<sup>th</sup> place, what was presented in table 2.

Table 2. Position of Poland and the Czech Republic compared to EU member states according to SSI.

	Human Well-being					Environmental Well-being					Economic Well-being						
	2006	2008	2010	2012	2014	2006	2008	2010	2012	2014	2006	2008	2010	2012	2014		
Czech Rep.	12	11	10	15	11	Poland	91	102	105	108	110	Czech Rep.	7	6	4	4	8
Poland	24	24	24	23	29	Czech Rep.	135	133	132	130	129	Poland	48	32	21	19	19

Source: based on Sustainable Society Index – Rankings (2014)

The position of Poland in the ranking of 151 observed countries on the basis of the SSI in the social dimension did not change considerably over eight years. Poland came 24<sup>th</sup> in 2006 and 29<sup>th</sup> in 2014, a drop of five positions. In the environmental dimension Poland occupied the 91<sup>st</sup> place in 2006 and fell to the 110<sup>th</sup> place in 2014, which indicates deterioration in the environmental performance. The position of Poland in the economic dimension underwent positive changes, as in 2006 the country came 48<sup>th</sup> and in 2014 – 19<sup>th</sup>, which means that, in accordance with the analysed indices, that is organic farming, genuine savings, gross domestic product, employment and public debt Poland gained a better result than Germany and the United Kingdom in 2014. It is worth noting that the Czech Republic among the presented countries in the economic dimension is the best. During the eight years, gained places between the fourth and eight.

### 3.2. Environmental Performance Index (EPI)

The environmental performance index measuring the ecological level of countries was devised at the American Universities of Columbia and Yale. The synthetic index was normalized within the scale of [0;100]. The first analysis took place in 2006 and comprised 146 countries. The Environmental Performance Index (EPI) is constructed through the calculation and aggregation of 20 indicators reflecting national-level environmental data. These indicators are combined into nine issue categories containing partial indices such as health impacts (child mortality), air quality (household air quality, air pollution), water and sanitation (access to drinking water and sanitation), water resources (wastewater treatment), agriculture (agricultural subsidies, pesticide regulation), forests (change in forest cover), fisheries (coastal shelf fishing pressure), biodiversity and habitat (natural biome protection, global biome protection, marine protected areas, critical habitat protection), climate and energy (trend in CO2 emissions, change of trend in carbon intensity, trend in carbon intensity).

Table 3. Position in the ranking according to the nine categories of EPI indicator.

Objectives	Categories	Position of Poland in the EPI rank	Position of the Czech Republic in EPI rank
Environmental Health	Health Impacts	25	1
	Air Quality	128	115
	Water and Sanitation	70	24
	Water Resources	33	24
	Agriculture	98	81
Ecosystem Vitality	Forests	32	44
	Fisheries	44	–
	Biodiversity and Habitat	28	13
	Climate and Energy	39	18

Source: own based on data from <http://epi.yale.edu/epi/country-rankings>

Table 4. Position of Poland and the Czech Republic in EPI ranking in 2014.

Countries	Position in ranking	Environmental Performance Index (EPI) [0;100]	Ten year change [%]
Czech Republic	5	81.47	3.47
Poland	30	69.53	2.67

Source: based on <http://epi.yale.edu/epi/country-rankings>

In 2014, in the ranking of 178 countries according to the EPI index Poland came 30<sup>th</sup>, with 69.53 out of the total of 100 points (table 5). The best results Poland gained in the areas of health impact (98.71) and biodiversity and habitat (91.76), which gave Poland the 25<sup>th</sup> and 28<sup>th</sup> place respectively. The lowest score was obtained in fisheries (26.52), which in the ranking gave Poland 44<sup>th</sup> place. The lowest position, the 128<sup>th</sup>, was gained by Poland in terms of air quality (70.74). While the Czech Republic ranked in the fifth position in the ranking (that is 25 positions higher than Poland). The highest scores were obtained consecutively in areas: health impact (the highest score 100 points), biodiversity and habitat (98.35), water and sanitation (97.91), water resources (75.68), air quality (73.99), agriculture (67.07), climate and energy (65.82) and forests (45.05). The analysis of the synthetic level of the EPI index and nine categories included in its composition indicates that Poland has only obtained a higher assessment than the Czech Republic in one area, i.e., in terms of forests (Poland 58.94 points, and the Czech Republic 45.05 points). However, in all other areas the Czech Republic was much higher rated than Poland. The biggest differences are in areas, such as: water resources, water and sanitation, what was presented in figure 2 and in tables 3 and 4.

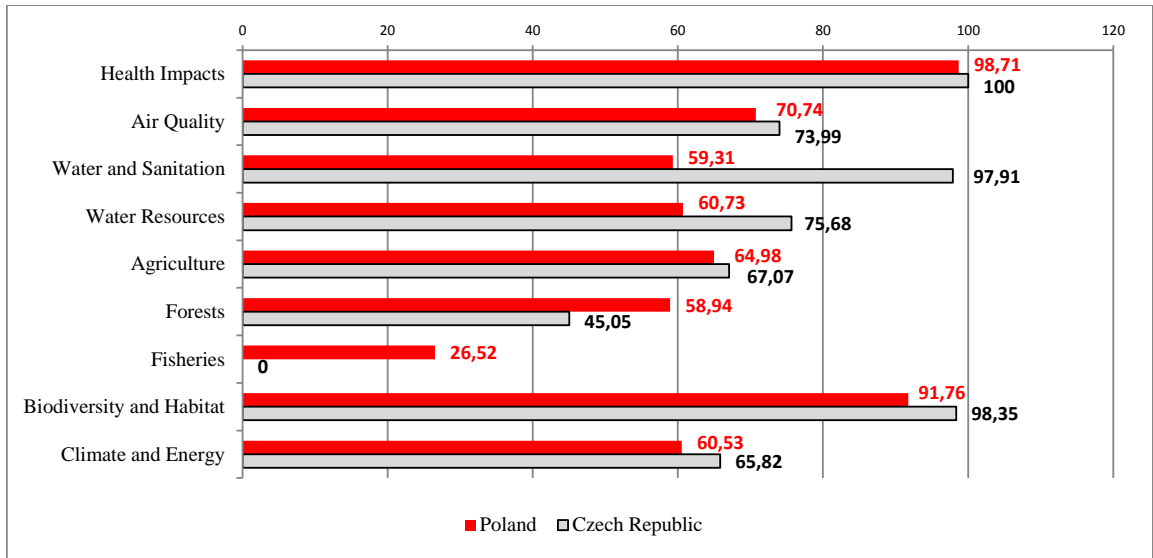


Fig. 2. Evaluation according to nine categories of EPI indicator. Source: own elaboration based on: <http://epi.yale.edu/epi/country-rankings>

3.3. Ecological footprint as a measure of natural resources consumption

Ecological Footprint, also called the ecological foot trace is one of relatively new measures that allows for the assessment of human pressure on the environment by the size of goods and services consumption. The value of the Ecological Footprint determines the surface of the biologically productive area, which is essential for meeting vital needs of the human population, taking into account the lifestyle (Wilczyńska-Michalik and Świder, 2010). It is measured with the land and sea surface, needed to produce the resources currently used by the mankind and to absorb the pollutants produced by men. The creator of the ecological footprint concept is Prof. Mathis Wackernagel, currently the director of the organisation of Global Footprint Network. In one of the interviews he stated that: ... analysing the global economy in the criteria of the ecological footprint resembles the accounting of our household incomes. We have to know how much we earn and how much we spend, because otherwise it will not be possible to predict the bankruptcy. This simple rule also refers to ecology (<http://ulicaekologiczna.pl>). Ecological Footprint identifies six categories of areas measured literally with the unit areas (so-called global hectares), i.e.: agricultural and farm use of the land, forests, fishing areas, urban areas, green areas absorbing carbon dioxide. The ecological footprint shows, above all, to what extent the areas with high industrialisation rely on natural resources located in other parts of the world. For each area we calculate the rate, expressed in area units, in global hectares per person (gha/p). On average, a person needs 2,7 gha/p., to meet his vital needs. Meanwhile, if we divide the production surface of our planet by the number of its inhabitants, it will turn out that there is only 2,1 gha per person. This means that we use more resources than the Earth is able to generate. EF calculations are regularly published in reports of WWF Living Planet 2012 (LPRB). Based on data presented on the websites of Global Footprint Network the estimations of the ecological footprint were presented for Poland and the Czech Republic in table 5.

Table 5. Ecological footprint and biocapacity level for Poland and the Czech Republic.

	ECOLOGICAL FOOTPRINT (global hectares per capita)		BIOCAPACITY (global hectares per capita)	
	Poland	The Czech Republic	Poland	The Czech Republic
Cropland Footprint	1.08	1.09	1.06	1.14
Grazing Footprint	0.03	0.15	0.12	0.12

Forest Footprint	0.77	1.01	0.72	1.23
Fishing Ground Footprint	0.13	0.06	0.11	–
Built-up Land	0.09	0.17	0.09	0.17
	Ecological Footprint of Consumption		Total Biocapacity	
	4.3	5.7	2.1	2.7

Source: own based on data from: The Ecological Footprint Atlas 2010. www.footprintnetwork.org/atlas

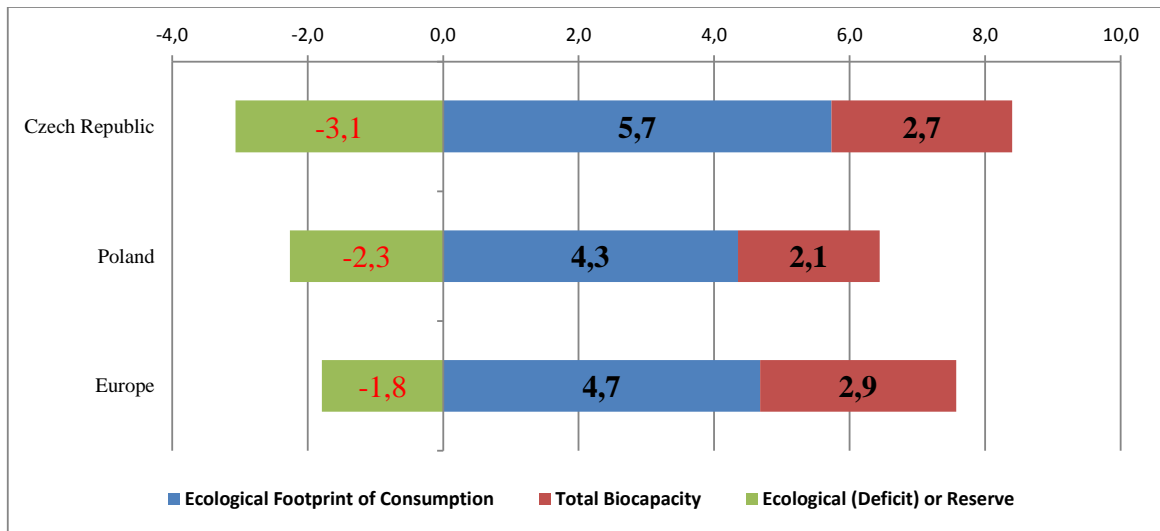


Fig. 3. Ecological footprint for Poland, the Czech Republic and the Europe

Source: own based on data from: The Ecological Footprint Atlas 2010. www.footprintnetwork.org/atlas

Both Poland and the Czech Republic belong to the countries with the ecological deficit, which is 3.1 for the Czech Republic and 2.3 for Poland. This means that we use almost two times more than the Earth can offer us, if all people used its resources to the same degree. While the ecological footprint for the Czech Republic is much higher than for Poland, as it is 5.7 and despite the country has a much higher biological capability than Poland (2.7) the ecological deficit of the Czech Republic is higher in comparison to Poland and amounts to 3.1. Overall, in Europe only 4 countries have ecological reserve, that means that they use less resources than their biological capacity, these are: Finland, Sweden, Lithuania and Estonia. Countries with the highest ecological deficit include: Belgium (6.7 gha/p); the Netherlands (5.2 gha/p); Spain, Italy and Greece with the deficit at the same level of 3.8 gha/p, Great Britain (3.6 gha/p), Denmark (3.4 gha/p), Germany and Portugal (3.2 gha/p). The ecological footprint can be calculated individually for each person or for a given group of people – organisation, society, nation, or for manufacturer or a type of production, like for example, the production of a specific product. Environmentalists seek to ensure that the ecological footprint is a permanently used measure of the economic development, supplementing the traditional gross domestic product index.

### 3.3 Synthetic indicator of sustainable development (SISD)

The methods of measurement and assessment of the sustainable development level on the international scale today constitute a current research problem, which requires a multidimensional analysis (Melecky, 2012). The aim of the studies conducted by the author was a relative assessment of the sustainable development level for the EU member states, which have been thoroughly presented in the publication (Bluszcz, 2015). While the current article has



presented the results of the comparative analysis of Poland and the Czech Republic due to selected diagnostic variable characterising three dimensions of the sustainable development: economic, social and environmental. The first group included the potential diagnostic variables describing the socio-demographic situation of Poland and Czech Republic, which concern the most important thematic areas, such as living conditions of the population (population density persons / km<sup>2</sup> and deaths per 1000 population), demographic changes characterising the percentage of people in the working age (employment rate of persons aged 15–64 in %) and public health described using the following criteria (infant deaths per 1000 live births and deaths per 1000 population). The economic dimension was characterised based on three potential diagnostic variables, i.e.: debt of the general government sector in % GDP, labour productivity (EU-27 = 100) and GDP per capita at purchasing power parity (current prices) EU-28 = 100. While the environmental dimension was described by two potential diagnostic variables such as: greenhouse gas emissions and total production of primary energy per capita in TOE. The results of the comparative analysis are presented in figure 4 and in tables 6 and 7.

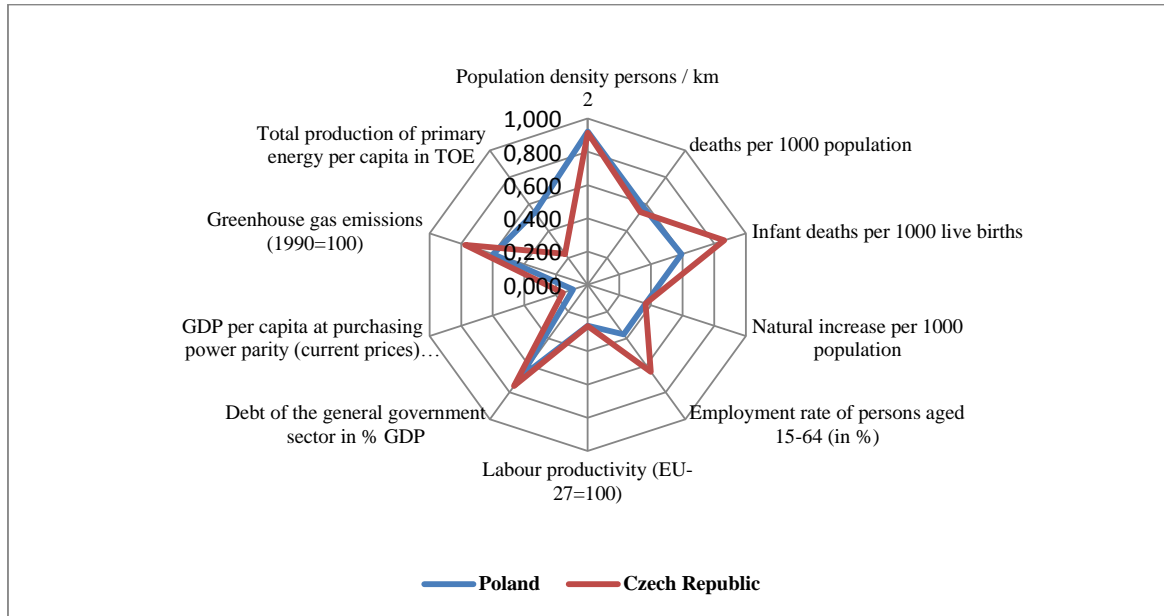


Fig. 4. Position of Poland and the Czech Republic according to SISD  
Source: own elaboration

Table 6. Position of Poland and the Czech Republic according to synthetic indicator of sustainable development in the three dimensions: social, economic and environmental separately.

Human dimension		Economic dimension		Environmental dimension				
Position in the rank	score	Position in the rank	score	Position in the rank	score			
12	Czech Republic	0.6667	17	Czech Republic	0.3862	16	Poland	0.5678
18	Poland	0.5653	22	Poland	0.3424	21	Czech Republic	0.5028

Source: own elaboration (more in Bluszcz, 2015, QQ)

Table 7. Position of Poland and the Czech Republic in the ranking according the synthetic indicator of sustainable development in the three dimensions together

Position in the rank		Value of synthetic indicator of sustainability
14	Czech Republic	0.5497
20	Poland	0.4989

Source: own elaboration (more in Bluszcz, 2015, QQ)

The results of the conducted comparative analysis for 28 EU member states have indicated that the Czech Republic has achieved a high 14<sup>th</sup> position in the ranking, while Poland was on the 20<sup>th</sup> position. In the assessment of the social dimension, the Czech Republic has achieved the 12<sup>th</sup> position, and the level of the synthetic developmental measure for the social dimension was 0.667, while Poland took the 18<sup>th</sup> place, with the score of 0.5653. In the economic dimension, the Czech Republic was slightly higher assessed than Poland, obtaining the score of 0.3862 what ensured the 17<sup>th</sup> position in the ranking, while Poland obtained the grade of 0.3424 what ensured the 22<sup>nd</sup> position. In the environmental dimension, Poland was on the 16<sup>th</sup> place in the ranking with the score of 0.5678, while the Czech Republic on the 21<sup>st</sup> position with the score of 0.5028.

#### 4. Discussions and Conclusions

The sustainable development indices are informative, diagnostic and decision-making tools for assessing the social, economic and environmental spheres on the regional, national and international level. Comparative analyses of levels of the examined indices over time are extremely useful in preparing and updating sustainable development strategies on the national level, the level of council bodies or sector strategies. The comparative analysis of Poland and the Czech Republic based on the synthetic measures has shown the closest results of the assessment according to SSI and SISD. According to the SSI index, 151 countries were assessed, while according to SISD, the EU member states were subjected to the assessment. The evaluation of the level of sustainable development according to the EPI index has shown the much higher level of the Czech Republic towards Poland according to the assessed areas. While, the assessment according to, the ecological footprint has shown much higher ecological deficit of the Czech Republic than Poland. Very important in the construction and aggregation of data into the synthetic measures is the access to uniform data. Different types of transformations can distort the final calculations. Therefore, numerous difficulties in the access and regarding the conformity, which diagnostic variables are the most relevant and comprehensively capture the issues of sustainable development. This publication does not exhaust the undertaken subject, and only paves the way for the further discussion in this regard.

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