Statistical evaluation of sustainable development of Polish voivodeships in respect of social domain

Małgorzata Stec[1], Małgorzata Wosiek[2]

Abstract

Sustainable development is a strategic concept, in which the process of integrating political, economic and social actions occurs, taking into account natural balance and stability of basic natural processes, in order to guarantee possibilities of fulfilling basic needs of separate societies or citizens not only of the contemporary generation, but future generations as well.

This article presents a statistical evaluation of the level of sustainable development of Polish voivodeships in respect of social domain in the years 2005-2015. The measures of sustainable development proposed by CSOP (Central Statistical Office of Poland - GUS) were used for the purpose of the research. To construct synthetic measure, we employed the General Distance Measure (GDM) method by M. Walesiak in terms of dynamic approach. The obtained results allowed to form a rank of Polish voivodeships in respect of the level of sustainable development in terms of social domain. We also determined the position of the podkarpackie voivodeship in a regional structure of the country in terms of a problem in question.

Keywords: *sustainable development, synthetic measures, generalized distance measure (GDM), voivodeships of Poland*

***JEL Classification*:** Q01, O12, B23

1 Introduction

The notion of sustainable development is not univocal (Beckerman, 1994; Holden and Linnerud, 2007; Hopwood et al., 2005; Luke, 2005). In general, Sustainable development is a kind of development that meets the needs of the present generation without compromising the needs of future generations to meet their own needs (Borys, 2005; Grzebyk and Stec, 2015; Piontek, 2002; Waas et al., 2010). According to the World Bank definition, Sustainable development recognizes that growth must be both inclusive and environmentally sound to reduce poverty and must build shared prosperity for today's population and to continue to meet the needs of future generations. It is efficient with resources and carefully planned to deliver both immediate and long-term benefits for people, planet, and prosperity (http://www.worldbank.org/en/topic/sustainabledevelopment/overview#1).

[1] Corresponding author: University of Rzeszów, Faculty of Economics, M. Ćwiklińskiej 2, 35-601 Rzeszów, e-mail: malgorzata.a.stec@gmail.com.

[2] University of Rzeszów, Faculty of Economics, M. Ćwiklińskiej 2, 35-601 Rzeszów, e-mail: mwosiek@ur.edu.pl.

Sustainable development is a basic and superior aim of the European Union. Sustainable development is mentioned next to Smart growth and development supporting the Inclusive growth as one of the main priorities of the Europe 2020 Strategy (http://ec.europa.eu/eu2020; Stec and Grzebyk, 2016). In achieving the assumed objectives of 2020 Strategy, it is important to systematically monitor their implementation not only on the national level, but also on the regional or even local one.

The purpose of the article is a statistical evaluation of the level of sustainable development of Polish voivodeships in respect of a social domain, with particular emphasis on the podkarpackie region. Based on statistical indicators characterizing the sustainable development with reference to social domain, synthetic measures for Polish voivodeships were calculated. The rank is prepared using the dynamic approach of the General Distance Measure (GDM) method by M. Walesiak. The study was conducted in the years 2005-2015.

2 Sustainable development indicators of Polish voivodeships in a social aspect

The indicators of sustainable development are grouped in four main areas describing: Social domain, Economic domain, Environmental domain and Institutional and political domain (http://wskaznikizrp.stat.gov.pl). This article aims at evaluating a social aspect of sustainable development of Polish voivodeships. The set of 32 variables was used as a basis of the evaluation for the sustainable development of Polish voivodeships. The set consists of 10 areas determining: demographic changes, public health, poverty and living conditions, education, access to labour market, poverty and living conditions, sustainable consumption patterns, old-age income adequacy, determinants of health, road accidents, criminality.

Demographic changes:

X1- Natural increase per 1000 population (S), X2- Total fertility rate (S), X3- Ratio of balance of permanent migration person at working age (S), X4- Demographic dependency ratio (D),

Public health:

X5- Infant deaths per 1000 live births (D), X6- Life expectancy at birth by sex: males (S), X7- Life expectancy at birth by sex: females (S), X8- Deaths by selected causes of death in percentage of total: diseases of the circulatory system (D), X9- Deaths by selected causes of death in percentage of total: neoplasms (D), X10- Deaths by selected causes of death in percentage of total: diseases of the respiratory system (D), X11- Suicide rate for 10 thous. population (D),

Poverty and living conditions:

X12- The average number of people in a household receiving social benefits in relation to the average number of persons per household (D), X13- Average monthly available income per capita in private households (S),

Education:

X14- Adult persons participating in education and training (S), X15- Children covered by pre-school education in percentage of the total number of children at the age 3-5 (S), X16- Ratios the quality of education and the level of students' knowledge: At the secondary level - passing the exam maturity examination in relation to the national average (S),

Access to labour market:

X17- Employment rate of disabled persons S, X18- People at the age of 18-59 living in jobless households (D), X19- Long-term unemployed persons in registered unemployed persons total (D), X20- Unemployment rate (LFS) (D),

Sustainable consumption patterns:

X21- Number of passenger cars per 1000 population (D), X22- Consumption of electricity in households during the year per capita (D), X23- Consumption of gas in households during the year per capita (D), X24- Consumption of water in households during the year per capita (D), X25- Average monthly consumption of meat per capita (D), X26- Average monthly consumption of vegetables per capita (S),

Old-age income adequacy:

X27- Average monthly gross retirement pensions from non-agricultural social security system in relation to average monthly gross wages and salary (S),

Determinants of health:

X28- Entitled to practise doctors per 10 thous. population (S), X29- Persons injured in accidents at work per 1000 employed persons (D),

Road accidents:

X30- Fatal victimsof road accidents per 100 thous. registered motor (D),

Criminality:

X31- Ascertained crimes in completed preparatory proceedings per 1000 population (D), X32- Rate of detectability of the delinquents of ascertained crimes (S).

3 Methods applied

The initial stage of a taxonomic study is to choose diagnostic variables. Diagnostic variables should be characterised by a sufficiently high level of variability and low level of correlation.

Most frequently the classical coefficient of variation (v_j) is assumed as a measure for variability. To evaluate the correlation between variables, Pearson correlation coefficient is used. Diagnostic variables are then employed as a basis for a synthetic measure construct according to a chosen method. In this study General Distance Measure (GDM) method by M. Walesiak[3] was used. This method uses an idea of generalised correlation coefficient including Pearson correlation coefficient and Kendall rank correlation coefficient (Walesiak, 2011).

According to GDM, the procedure of linear ordering of objects comprises of the following stages (Walesiak, 2011):

- data matrix is a starting point:

$$\mathbf{X} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \tag{1}$$

where:

x_{ij} - value of j-th features *(j= 1,2,...,m)* in i-th object *(i=1,2,..., n)*.

- defining the type of variables (stimulants, destimulants)[4],
- a normalization of the variable values is conducted using the following formulas: (Wysocki, 2010):

$$z_{ij} = \frac{x_{ij} - \min\limits_{i}\{x_{ij}\}}{R_j} \quad \text{for stimulating factors} \tag{2}$$

$$z_{ij} = \frac{\max\limits_{i}\{x_{ij}\} - x_{ij}}{R_j} \quad \text{for non-stimulating factors} \tag{3}$$

Normalisation formulas are valuable because they provide diverse variability and simultaneously fixed range for normalised values of variables (Walesiak and Gatnar (eds.), 2009).

- determining coordinates of a model (high point of development) i.e. the most favourable values of the variables for stimulants and destimulants[5].

[3] This is one of the latest methodological solutions, computational procedure is available in the *R* software (Walesiak and Dudek, 2014).

[4] The notion of stimulant (S) and destimulant (D) was introduced by Hellwig (1968). Stimulants are features, whose high values are, from a given point of view, desirable phenomena (e.g. level of socio-economic development), while low values are undesirable. Destimulants on the other hand, are features whose low values are, from a given perspective, desirable occurrences, while its high values are undesirable.

[5] The coordinates of a model can be also determined with lower point of development, i.e. the least favourable values of the variables for stimulant and destimulant.

- determining distance of each objects from an object-model with the help of General Distance Measure (GDM) for metric data:

$$d_{ik} = \frac{1}{2} - \frac{\sum_{j=1}^{m}(z_{ij} - z_{kj})(z_{kj} - z_{ij}) + \sum_{j=1}^{m}\sum_{\substack{l=1 \\ l \neq i,k}}^{n}(z_{ij} - z_{lj})(z_{kj} - z_{lj})}{2\left[\sum_{j=1}^{m}\sum_{l=1}^{n}(z_{ij} - z_{lj})^2 \cdot \sum_{j=1}^{m}\sum_{l=1}^{n}(z_{kj} - z_{lj})^2\right]^{\frac{1}{2}}} \quad (4)$$

where:

$i, k, l = 1,\ldots,n$ – numbers of objects,

$j=1,\ldots,m$ – number of a variable,

m – number of variables,

z_{ij} (z_{kj}, z_{lj}) – normalised j value for a variable for i (k, l) object.

- Arranging the elements of a collection of objects according to GDM (high point of development). If a studied object gains lower values of synthetic measure, it has the higher level of development.

The value of the resulting synthetic measure may serve as the basis for allocating objects (e.g. voivodeships of Poland) into groups of similar levels of sustainable development in respect of social domain. An allocation scheme based on the arithmetic mean and standard deviation of the synthetic measure is also applicable in such circumstances (Nowak, 1990):

group I: $GDM_i < \acute{s}rGDM_i - S_{GDM_i}$ high level

group II: $\acute{s}rGDM_i > GDM_i \geq \acute{s}rGDM_i - S_{GDM_i}$ medium-high level (5)

group III: $\acute{s}rGDM_i + S_{GDM_i} > GDM_i \geq \acute{s}rGDM_i$ medium-low level

group IV: $GDM_i \geq \acute{s}rGDM_i + S_{GDM_i}$ low level

where: $\acute{s}rGDM_i$ - mean value of overall synthetic measure, S_{GDM_i} - standard deviation of overall synthetic measure.

4 Empirical results

Values for all variables proposed for evaluation of the level of sustainable development of Polish voivodeships in respect of social domain were collected between year 2005 and 2015, i.e. for 11 years. Then, the level of differentiation of each variable was checked and correlation coefficients were designated between them. The following variables had a low level of variability $(v_j \leq 0.10)$, during all these years taken into consideration: X2, X4, X6,

X7, X8, X9, X12, X16, X21, X25, X26, X27, X32. They were removed from the initial set of variables. The conducted analysis of correlation between the respective variables using Pearson's linear correlation did not indicated their strong correlation. The set of diagnostic variables used to evaluate the level of sustainable development of Polish voivodeships in respect of social domain included 19 variables. On its basis it was possible to determine synthetic measures with GDM for each voivodeship in 2005-2015. It should be emphasised that the calculations were done in a dynamic manner, using the so called 'object-periods'.

Table 1. shows value of synthetic measures calculated with GDM for Polish voivodeships in 2005-2015.

Voivodeships	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
DO	0.52	0.51	0.49	0.48	0.52	0.53	0.52	0.53	0.56	0.48	0.47
KP	0.40	0.44	0.44	0.41	0.44	0.40	0.46	0.44	0.43	0.45	0.46
LL	0.18	0.18	0.19	0.27	0.27	0,26	0,28	0,26	0,27	0,28	0,29
LS	0,49	0,51	0,51	0,49	0,52	0,53	0,57	0,53	0,56	0,50	0,50
LO	0,38	0,39	0,41	0,44	0,44	0,35	0,37	0,39	0,41	0,41	0,45
ML	0,27	0,25	0,29	0,27	0,29	0,28	0,26	0,27	0,25	0,25	0,25
MZ	0.41	0.39	0.33	0.36	0.36	0.36	0.35	0.35	0.37	0.37	0.37
OP	0.36	0.44	0.40	0.40	0.37	0.45	0.38	0.45	0.44	0.43	0.42
PK	0.26	0.27	0.28	0.30	0.29	0.33	0.34	0.36	0.34	0.39	0.39
PD	0.18	0.22	0.26	0.25	0.27	0.26	0.22	0.23	0.27	0.34	0.36
PM	0.43	0.42	0.42	0.38	0.39	0.35	0.34	0.28	0.33	0.32	0.29
SL	0.45	0.44	0.42	0.42	0.40	0.40	0.39	0.35	0.31	0.34	0.34
SW	0.29	0.29	0.31	0.30	0.25	0.29	0.34	0.28	0.35	0.36	0.39
WM	0.52	0.47	0.52	0.48	0.50	0.53	0.45	0.47	0.41	0.45	0.47
WK	0.38	0.42	0.43	0.43	0.45	0.41	0.43	0.48	0.43	0.45	0.43
ZP	0.61	0.60	0.59	0.54	0.59	0.54	0.56	0.52	0.51	0.51	0.49

Table 1. Values of Synthetic Measures (GDM) for Polish voivodeships[6] in 2005-2015.

[6] DO-dolnośląskie, KP-kujawsko-pomorskie, LL-lubelskie, LS-lubuskie, LO-łódzkie, ML-małopolskie, MZ-mazowieckie, OP-opolskie, PK-podkarpackie, PD-podlaskie, PM-pomorskie, SL-śląskie, SW-świętokrzyskie, WM-warmińsko-mazurskie, WK-wielkopolskie, ZP-zachodniopomorskie.

In years 2005-2015, the values of synthetic measure obtained by GDM for each voivodeship differ in regard to the value. During the researched period they do not show any significant uptrend or downward trend, they increase and decrease alternately. In 2005, the value of synthetic measure (GDM) for voivodeships oscillated from 0.18 to 0.61. In the rank of voivoideships, in relation to the calculated measure, among the best were: podlaskie, lubelskie, podkarpackie, małopolskie and świętokrzyskie; while at the end of the rank there were voievodeships such as: zachodniopomorskie, warmińsko-mazurskie, dolnośląskie, lubuskie and śląskie. In 2015, the value of synthetic measure (GDM) oscillated from 0.25 to 0.50. At the forefront of the rank, on the level of regional structure, in terms of analysed measure, there were voivodeships such as: małopolskie, pomorskie, lubelskie, śląskie and podlaskie. At the end of the rank there were: lubuskie, zachodniopomorskie, warmińsko-mazurskie, dolnośląskie and kujawsko-pomorskie voivodeships (table 1).

Voivodeships	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
DO	14	14	13	14	14	15	14	16	16	14	13
KP	9	12	12	9	11	9	13	10	11	11	12
LL	2	1	1	3	2	1	3	2	3	2	3
LS	13	15	14	15	15	14	16	15	15	15	16
LO	7	7	8	12	10	6	8	9	9	9	11
ML	4	3	4	2	4	3	2	3	1	1	1
MZ	10	6	6	6	6	8	7	6	8	7	6
OP	6	10	7	8	7	12	9	11	13	10	9
PK	3	4	3	5	5	5	6	8	6	8	8
PD	1	2	2	1	3	2	1	1	2	4	5
PM	11	9	10	7	8	7	4	4	5	3	2
SL	12	11	9	10	9	10	10	7	4	5	4
SW	5	5	5	4	1	4	5	5	7	6	7
WM	15	13	15	13	13	13	12	12	10	12	14
WK	8	8	11	11	12	11	11	13	12	13	10
ZP	16	16	16	16	16	16	15	14	14	16	15

Table 2. Ranks of Polish voivodeships in terms of values of synthetic measure calculated with General Distance Measure (GDM) in years 2005-2015.

Based on the data provided in table 2, it can be inferred that between years 2005-2015, the positions in the ranking of voivodeships in terms of synthetic measure obtained with GDM are quite stable. Improvement of ranks of voivodeships in 2015 in comparison to 2005 can be noticed for 7 voivodeships. The following voivodeships underwent the greatest positive changes: pomorskie (from position 11 in 2005 to position 2 in 2015), śląskie (from 12 to 4) and mazowieckie (from 10 to 6); whereas 9 voivodeships noted downgrade in the ranks, the highest drop for podkarpackie voivodeship (from position 3 in 2005 to position 8 in 2015), łódzkie (from 7 to 11), podlaskie (from 1 to 5).

In years 2005-2015, podkarpackie voivodeship recorded a systematic drop of its position in relation to other voivodeships, which is an alarming phenomenon. However, it should be acknowledged that the social domain of the sustainable development of podkarpackie voivodeship is quite a strong advantage. In other socio-economic domains it comes out worse than other voivodeships (Stec, 2012).

Using a classification outline (formula no 5), we provided a classification of Polish voivodships in relation to different levels of sustainable development in social domain in years 2005 and 2015 (table 3).

Level	**Year**	
	2005	**2015**
High	podlaskie, lubelskie, podkarpackie,	małopolskie, pomorskie, lubelskie,
Medium- high	małopolskie, świętokrzyskie, opolskie, łódzkie, wielkopolskie,	śląskie, podlaskie, mazowieckie, świętokrzyskie, podkarpackie,
Medium- low	kujawsko-pomorskie, mazowieckie, pomorskie, śląskie, lubuskie,	opolskie, wielkopolskie, łódzkie, kujawsko-pomorskie, dolnośląskie, warmińsko-mazurskie,
Low	dolnośląskie, warmińsko-mazurskie, zachodniopomorskie.	zachodniopomorskie, lubuskie.

Table 3. Groups of Poland voivodeships with similar levels of sustainable development in respect of social domain in 2005 and 2015.

Three Poland voivodeships, podlaskie, lubelskie, podkarpackie, attained a high level of sustainable development in respect of social domain in 2005. The group of medium-high level comprises 5 voivodships małopolskie, świętokrzyskie, opolskie, łódzkie, wielkopolskie. Medium- low levels showed by voivodeships kujawsko-pomorskie, mazowieckie, pomorskie,

śląskie, lubuskie. Dolnośląskie, warmińsko-mazurskie, zachodniopomorskie belong to the group of low level.

High levels of sustainable development in respect of social domain was, in 2015, showed by voivodeships małopolskie, pomorskie, lubelskie. Most voivodeships of Poland belong to the group of medium-high (5 voivodeships) and medium-low levels (6 voivodeships). Zachodniopomorskie and lubuskie are the voivodeships which belong to the group of the lowest level of sustainable development in respect of social domain (table 3).

Conclusions

In this article, the comparison of Polish voivodeships in terms of the level of the sustainable development in years 2005-2015 was conducted. The measures of the sustainable development in social domain proposed by CSOP were used for analysis. The General Distance Measures (GDM) method by M. Walesiak was employed for the empirical studies. The results confirm the diversity of Polish regions in social terms of sustainable development. The position of podkarpackie voivodeship in the regional structure of the country in relation to the studied problem can be deemed as quite good. However, its systematic downgrade in the rank is alarming. The results of the research concerning the sustainable level in social domain can be used for the initial evaluation of sustainable level for all voivodeships. It would be interesting to conduct the similar research for other aspects of the sustainable growth, i.e. Economic domain, Environmental domain and Institutional and political domain.

References

Beckerman, W. (1994). 'Sustainable development': is it a useful concept?. *Environmental values*, *3*(3), 191-209.

Borys, T. (2005). Pomiar trwałego i zrównoważonego rozwoju [w:] Zrównoważony rozwój. *Wybrane problemy teoretyczne i implementacja w świetle dokumentów Unii Europejskiej*, 126-143.

Grzebyk, M., & Stec, M. (2015). Sustainable development in EU countries: concept and rating of levels of development. *Sustainable Development*, *23*(2), 110-123.

Hellwig, Z. (1968). Zastosowanie metody taksonomicznej do typologicznego podziału krajów ze względu na poziom ich rozwoju i strukturę wykwalifikowanych kadr. *Przegląd Statystyczny, (4)*, 323-326.

Holden, E., & Linnerud, K. (2007). The sustainable development area: satisfying basic needs and safeguarding ecological sustainability. *Sustainable Development*, *15*(3), 174-187.

Hopwood, B., Mellor, M., & O'Brien, G. (2005). Sustainable development: mapping different approaches. *Sustainable Development, 13*(1), 38-52.

Luke, T. W. (2005). Neither sustainable nor development: reconsidering sustainability in development. *Sustainable Development, 13*(4), 228-238.

Nowak, E. (1990). *Metody taksonomiczne w klasyfikacji obiektów społeczno-gospodarczych,* Państwowe Wydaw. Ekonomiczne, 93.

Piontek, B. (2002). *Koncepcja rozwoju zrównoważonego i trwałego Polski*. Wydaw. Naukowe PWN, 27.

Stec, M. (2012). Analiza rozwoju społeczno-gospodarczego województwa podkarpackiego w latach 1999-2009 [w:] M*odelowanie i prognozowanie zjawisk społeczno-gospodarczych. Aktualny stan i perspektywy rozwoju.* Wydaw. Uniwersytetu Ekonomicznego w Krakowie, 107-118.

Stec, M., & Grzebyk, M. (2016). The implementation of the Strategy Europe 2020 objectives in European Union countries: the concept analysis and statistical evaluation, *Quality & Quantity*, DOI 10.1007/s11135-016-0454-7

Waas, T., Verbruggen, A., & Wright, T. (2010). University research for sustainable development: definition and characteristics explored. *Journal of Cleaner Production, 18*(7), 629–636.

Walesiak, M. (2011). *Uogólniona miara odległości GDM w statystycznej analizie wielowymiarowej z wykorzystaniem programu R*. Wydawnictwo Uniwersytetu Ekonomicznego, 38; 74-76.

Walesiak, M., & Dudek, A. (2014). *ClusterSim Package, URL*, http://www.R-project.org.

Walesiak, M., & Gatnar, E. (Eds.). (2009). *Statystyczna analiza danych z wykorzystaniem programu R*. Wydawnictwo Naukowe PWN, 67.

Wysocki, F. (2010). *Metody taksonomiczne w rozpoznawaniu typów ekonomicznych rolnictwa i obszarów wiejskich*. Wydawnictwo Uniwersytetu Przyrodniczego w Poznaniu, Poznań, 51.