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PRO-ENVIRONMENTAL ACTIVITIES IN POLAND IN 2015 (REGIONAL STUDY)

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ABSTRACT

The author of the article sets out to perform two tasks. The first is an attempt to present the construction techniques of a ranking of items (in this case – voivodships) in terms of the level of a complex phenomenon, and then to present a method of division of items into groups with similar values of the synthetic variable.
The second goal is to present the condition of pro-environmental activities in Poland in 2015 in the regional system. In order to implement this objective, diagnostic variables have been selected, describing the condition of activities for environmental protection. Based on the following criteria: substantive and sufficient variability, 11 diagnostic features have been selected. These variables constitute the basis for multiple criteria evaluation of a complex phenomenon (pro-environmental activities).
Based on the described procedures, a ranking of voivodeships has been created on the basis of the status of pro-environmental activities in Poland. The set of items (voivodships) has been divided into 3 groups: group I – voivodships with a high level of pro-environmental activities, group II – voivodships with an average level, and group III with a relatively low level. The quantitative proportions of voivodships in particular groups are as follows, respectively: 4 : 6 : 6.

Key words: environmental protection, voivodship, diagnostic variable, synthetic variable, ranking

INTRODUCTION

The first ideas related to the need for environmental protection were created in the 2nd half of the 19th century. In this period, the USA and Europe observed a rapidly progressing process of industrialisation along with migration of the population from rural areas to industrial centres. The cities quickly increase the number of their inhabitants and their surface area. Completely new municipal centres also appear. All the above causes growing concerns in the face of destruction of natural resources as well as creation of hazards to life and health of the population. This problem raised the interest of the luminaries of science and literature. The word "ecology" was for the first time introduced to the terminology of natural sciences by a German biologist Ernst Haeckl (1834–1919). It took place in the 2nd half of the 19th century. In the USA, one of the first people to take interest in this issue was David Thoreau.

In Poland, the process of industrialisation that progressed quickly after World War II provided many new jobs, opening possibilities of social advancement for many young Poles, but in its initial phase, the damages it causes to the natural environment were not taken into account. These events were also connected with the growing urbanisation of the country. All the above, after the initial euphoria of the rulers and the media acting on their referral, induced the general society to seriously reflect on the issues of environmental hazards. A number

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of initiatives were undertaken, the purpose of which was to counteract the progressing process of its degradation. Currently, the state and the local government authorities allocate significant funds for pro-environmental activities. Pro-environmental activities and their numerous aspects are described in more detail in the work of Matczak [2000].

The primary purpose of this article is to perform a synthetic evaluation of all pro-environmental actions undertaken in particular voivodships of our country. It has been assumed that pro-environmental activities are a phenomenon so complex that it should be described by means of more than ten variables, hereinafter referred to as diagnostic variables. The research uses methods within the scope of multi-dimensional comparative analysis. The final result of the applied procedures is creation of a ranking of voivodships on the basis of the level of a complex phenomenon, namely the undertaken pro-environmental activities. Therefore, the author wanted to show any possible regional disproportions in this respect.

Selection of diagnostic features

Selection of diagnostic variables (features) in the process of construction of a ranking of items on the basis of the level of a complex phenomenon is an extremely important activity, as it radically affects its structure.

The s of diagnostic variables ($X_1, \ldots, X_s$) selected from among their greater number are to describe the level of the examined complex phenomenon in r items ($0_1, \ldots, 0_r$). Therefore, the value of the j-th variable in i-th item is marked as x_{ij}. When selecting diagnostic features, two criteria have been taken into account:

- substantive, taking account of the importance of the feature in the characteristics of the complex phenomenon,
- sufficient variability of a feature classified to the set of characteristics describing them.

The criterion of sufficient variability is defined by two conditions that the selected feature must simultaneously meet: $V(X_j) > 0.1$ and $I(X_j) > 2$.

Whereas:

$$V(X_j) = \frac{S(X_j)}{\overline{X}_j}, \qquad \overline{X}_j > 0, \qquad (j = 1, \ldots, s) \tag{1}$$

and

$$I(X_j) = \frac{\max_i x_{ij}}{\min_i x_{ij}}, \qquad \min_i x_{ij} > 0, \qquad (i = 1, \ldots, r) \tag{2}$$

The following variables have been selected on the basis of the aforementioned criteria:

X_1 – the share of legally protected areas in the voivodship's surface area (%),
X_2 – the surface area of legally protected areas per 1 inhabitant (m^2),
X_3 – the share of industrial and municipal sewage drained through the sewerage network in the overall volume of industrial and municipal sewage (%),
X_4 – the share of non-treated industrial and municipal sewage to treated industrial and municipal sewage (%),
X_5 – outlays for sewage management and water protection per 1 inhabitant (PLN),
X_6 – outlays for waste management per 1 inhabitant (PLN),
X_7 – selectively collected waste per 1 inhabitant (kg),
X_8 – outlays for protection of air and climate per 1 km^2 (PLN),
X_9 – outlays for reduction of noise and vibrations per 1 km^2 (PLN),
X_{10} – outlays for public sewage treatment plants per 1 inhabitant (PLN),
X_{11} – outlays for fixed assets used for environmental protection per 1 km^2 (PLN).

METHOD OF CONSTRUCTION OF A RANKING OF ITEMS ON THE BASIS OF THE LEVEL OF A COMPLEX PHENOMENON

Bearing in mind that each complex phenomenon is described by several diagnostic variables: at least two – definition of a complex phenomenon [Kukuła 2000] – these features varied in terms of size and dimension should be unified. It is also necessary to remember that the aforementioned features may differ in nature, i.e. growth in some positively affects the level of evaluation of a complex phenomenon, and growth in other variables negatively impacts the evaluation of the examined phenomenon. The former variables belong to the set of *boosters* (*S*), while the latter form the set of *dampers* (*D*). There are also features that behave like boosters only up to a certain value, and from a certain level of the value the act as dampers. Those variables are *neutral variables* (*N*). This study features only variables that are boosters or dampers.

The identified features, with regard to their nature, still have various dimensions and size ranges, so they cannot be directly compared and added. In order to make them comparable and additive, the procedure of standardisation of diagnostic features should be used through one of the standardisation methods. There are several standardisation methods [Hellwig 1968, Pluta 1977, Borys 1978, Nowak 1990, Strahl 1990]. Nonetheless, a procedure meeting all standardisation conditions that are imposed on methods of linear ordering is *the zero unitarisation method* (abbrev. ZUM).

Assuming that, after selection, we have *p* of selected diagnostic variables in *r*, of items, this piece of information can be presented in the form of an **X** matrix:

$$\mathbf{X} = \left[x_{ij}\right] = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1p} \\ x_{21} & x_{22} & \dots & x_{2p} \\ \dots & \dots & \dots & \dots \\ x_{r1} & x_{r2} & \dots & x_{rp} \end{bmatrix}, \quad \begin{pmatrix} i = 1, \dots, r \\ j = 1, \dots, p \end{pmatrix} \tag{3}$$

where: x_{ij} – value of *j*-th diagnostic variable in *i*-th item.
Standardisation consists in transformation of feature X_j into variable Z_j deprived of dimension and meeting specific conditions.
Standardisation of booster features ($X_j \in S$) in ZUM is performed using the following formula:

$$z_{ij} = \frac{x_{ij} - \min\limits_i x_{ij}}{\max\limits_i x_{ij} - \min\limits_i x_{ij}} \tag{4}$$

While damper features ($X_j \in D$) are standardised by means of the following formula:

$$z_{ij} = \frac{\max\limits_i x_{ij} - x_{ij}}{\max\limits_i x_{ij} - \min\limits_i x_{ij}} \tag{5}$$

Features standardised using formulas (4) and (5) meet all the conditions of comparability and additivity, since their values have a constant interval of variability:

$$z_{ij} \in [0, 1] \tag{6}$$

For boosters:

$$z_{ij} = 0 \text{ when } x_{ij} = \min_i x_{ij}$$

$$\text{and} \quad z_{ij} = 1 \text{ when } x_{ij} = \max_i x_{ij} \quad (7)$$

While for dampers we have:

$$z_{ij} = 0 \text{ when } x_{ij} = \max_i x_{ij}$$

$$\text{and} \quad z_{ij} = 1 \text{ when } x_{ij} = \min_i x_{ij} \quad (8)$$

The transformed original values of diagnostic variables according to the formulas (4) and (5) form a matrix of standardisations:

$$\mathbf{Z} = \left[z_{ij} \right] = \begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1p} \\ z_{21} & z_{22} & \cdots & z_{2p} \\ \cdots & \cdots & \cdots & \cdots \\ z_{r1} & z_{r2} & \cdots & z_{rp} \end{bmatrix}, \quad \begin{pmatrix} i = 1, 2, ..., r \\ j = 1, 2, ..., p \end{pmatrix} \quad (9)$$

Standardisations of diagnostic features contained in the formula (9) meet the principle of additivity. Therefore, they allow for determining the value of the synthetic variable (Q_i) for each item with the use of the following formula:

$$Q_1 = \frac{1}{p}\sum_{j=1}^{p} z_{ij}, \qquad (i = 1, \ldots, r) \quad (10)$$

Values of the synthetic variable designated this way constitute multiple-criteria evaluation of each of the r of examined objects. On the basis of these evaluations, the construction of a ranking can commence, classifying items from the best one $\left(\max_i Q_i \right)$ – the first item in the ranking – to the weakest one, holding the last r-th position in the ranking $\left(\min_i Q_i \right)$ It is worth mentioning the fact that synthetic variables also have standardised values:

$$Q_j \in [0, 1], (i = 1, \ldots, r) \quad (11)$$

Later, the range of the synthetic variable should be determined using the formula:

$$R(Q_i) = \max_i Q_i - \min_i Q_i \quad (12)$$

Items that are contained in the ranking are ordered non-ascendingly, according to the attributable value of synthetic variable. Our goal is to divide the set of r items into k groups: G_1, G_2, …, G_k. The group number is marked with the l symbol, where ($l = 1, 2, \ldots, k$) and $k \le r$. Assuming that the empirical distribution of the synthetic variable Q is similar to the uniform (rectangular) distribution, division of all items included in the ranking into k groups has been proposed, in a manner which is described by the general formula:

$$G_l \text{ for } Q_i \in \left[\min_i Q_i + \frac{k-l}{k} R(Q_i),\ \min_i Q_i + \frac{k-l+1}{k} R(Q_i)\right], \quad \begin{pmatrix} l = 1, 2, ..., k \\ i = 1, 2, ..., r \end{pmatrix} \tag{13}$$

In our research, with a relatively small set of items ($r = 16$ voivodships), it was deemed purposeful to divide them into 3 groups ($k = 3$). Using the general formula (13) for division into groups, the ranges of the synthetic variable values relevant for each of the three groups have been determined:
- G_1 – the group with the high level of the examined phenomenon;
- G_2 – the group with the average level of the phenomenon;
- G_3 – the group with the low level of this phenomenon.

And so:

$$G_1 \text{ for } Q_i \in \left[\min_i Q_i + \frac{2}{3} R(Q_i),\ \min_i Q_i + R(Q_i)\right] \tag{14}$$

$$G_2 \text{ for } Q_i \in \left[\min_i Q_i + \frac{1}{3} R(Q_i),\ \min_i Q_i + \frac{2}{3} R(Q_i)\right] \tag{15}$$

$$G_3 \text{ for } Q_i \in \left[\min_i Q_i,\ \min_i Q_i + \frac{1}{3} R(Q_i)\right], \quad (l = 1, 2, 3) \tag{16}$$

RESULTS OF THE STUDY

When evaluating the results of the conducted study, it is impossible to ignore the results defining the degree of variability of selected diagnostic features. The highest degree of variability from among the eleven selected variables have been found in 4 features:

- X_9 – outlays for reduction of noise and vibrations (PLN·1 km^{-2}), [$V(X_9) = 1.64$; $I(X_9)9 \cong 42$];
- X_4 – percentage share of industrial and municipal sewage drained through the sewerage network in the overall volume of treated sewage, [$V(X_4) = 1.65$; $I(X_4)1 \cong 83$],
- X_8 – outlays for protection of air and climate (PLN·km^{-2}), [$V(X_8) = 0.95$; $I(X_8)\ 6 \cong 9$];
- X_6 – outlays for waste management (PLN·person^{-1}), [$V(X_6) = 0.99$; $I(X_6) \cong 40$].

The aforementioned features most heavily differentiate particular voivodships and therefore are variables desired when constructing their ranking. This ranking is supposed to assess the degree of involvement of voivodships in pro-environmental activities in their area.

Another action that has been undertaken is standardisation of original variables contained in Table 1. Using formulas (4) and (5), they have been standardised. Original features are unified with regard to size, without dimensions, and are additive. Thus they can be added. As a result of application of the formula (10), values of the synthetic variable Q_i have been determined. This variable is a multiple criteria evaluation of each of the sixteen voivodeships. The greater its value, the higher position the given voivodeship holds in the ranking. Synthetic variables ordered non-ascendingly are the basis for construction of the ranking of voivodships due to the pro-environmental activities undertaken by these units. Their ranking is presented in Table 1.

Table 1. Ranking of voivodships on the basis of the level of pro-environmental activities in 2015

Rank	Voivodship	Values of the synthetic variable Q_i	Group
1	Małopolskie	0.519	$Q_i \in [0.432; 0.519]$ I (4 voivodships)
2	Śląskie	0.493	
3	Lubuskie	0.459	
4	Pomorskie	0.448	
5	Mazowieckie	0.409	$Q_i \in [0.346; 0.432]$ II (6 voivodships)
6	Łódzkie	0.403	
7	Wielkopolskie	0.392	
8	Podlaskie	0.357	
9	Opolskie	0.352	
10	Kujawsko-Pomorskie	0.350	
11	Dolnośląskie	0.339	$Q_i \in [0.259; 0.346]$ III (6 voivodships)
12	Warmińsko-Mazurskie	0.334	
13	Podkarpackie	0.309	
14	Świętokrzyskie	0.300	
15	Lubelskie	0.266	
16	Zachodniopomorskie	0.259	
	$I(Q_i)$	2.004	

Source: Prepared by the author.

Later, the voivodships have been divided into 3 groups using the procedure described with formulas (13–16):

- Group I contains items with a high level of pro-environmental activities;
- Group II contains items with an average level of pro-environmental activities;
- Group III contains items with a relatively low level of pro-environmental activities.

The first group, characterised by a relatively high degree of involvement in pro-environmental activities, includes 4 voivodships: Małopolskie, Śląskie, Lubuskie and Pomorskie.

The second group, with the average level of pro-environmental activities, includes 6 voivodships: Mazowieckie, Łódzkie, Wielkopolskie, Podlaskie, Opolskie, and Kujawsko-Pomorskie.

The third group, with the relatively low level of pro-environmental activities, also contains 6 voivodships: Dolnośląskie, Warmińsko-Mazurskie, Podkarpackie, Świętokrzyskie, Lubelskie, and Zachodniopomorskie.

Analysis of Figure 1, illustrating the spatial layout of voivodships due to the examined complex phenomenon, induces to formulate three questions:

1. Is the intensity of activities for environmental protection in Poland spatially diverse?
2. What is the evaluation of the degree of these differences?
3. What is the spatial distribution of the level of pro-environmental activities between voivodships?

With regard to the first issue, it should be stated that the level of pro-environmental activities in particular voivodships demonstrates some differences. Are these differences substantial? To answer the second issue raised, a quotient of extreme values of the synthetic variable Q_i has been used, calculated according to the formula (2). According to the obtained result [$I(Q_i) \cong 2$], the result for the Małopolskie Voivodship, holding the first position in the ranking, is slightly over twice as high as the result for the Zachodniopomorskie Voivodship, which is the last one in the ranking. When comparing results of other rankings [Kukuła 2014a, b, Kisielińska 2016], it should be stated that this degree of diversity is moderate or even low. This equalisation of levels of pro-environmental activities found in the examined items is an expression of the authorities of particular voivodships treating problems related to environmental protection seriously.

Fig. 1. Groups of voivodships due to the level of pro-environmental activities in 2015

Source: Prepared by the author.

In order to advance to the spatial analysis of the examined phenomenon, it is necessary to take a look at Table 1. It can be easily noted that voivodships of group I (the best one) are relatively small in number (4 items). Three of them (Małopolskie, Śląskie and Pomorskie) are strongly urbanised and industrialised units, emitting high amounts of harmful substances, in both liquid and gas form. Therefore, it is logical that they try to neutralise the negative effects of their business operations to some degree. One item left from this group is the Lubuskie Voivodship. This item is characterised by the greatest degree of forestation in Poland and is one of the cleanest voivodships. Therefore, it is observed that the authorities of this voivodship take care to ensure the quality of the natural environment, which can be seen in the form of outlays for improvement in its quality.

Group II, with the average level of pro-environmental activities, consists of 6 items. These are the following voivodships: Mazowieckie, Łódzkie, Wielkopolskie, Podlaskie, Opolskie, and Kujawsko-Pomorskie. These items have similar characteristics to items in the first group, but the degree of industrialisation is slightly lower than in the aforementioned group.

Group III also contains 6 items. This group includes the following voivodships: Dolnośląskie, Warmińsko-Mazurskie, Podkarpackie, Świętokrzyskie, Lubelskie, and Zachodniopomorskie. These items belong to voivodships with low degree of pollution (apart from Dolnośląskie Voivodship), and thus spend less funds on pro-environmental activities.

CONCLUSIONS

Considering the recommendations arising from the Polish legislation within the scope of environmental protection, the spatial distribution of shaping of this sphere of activities should be analysed. Construction of the ranking of voivodships constitutes an up-to-date image of the condition of pro-environmental activities implemented in particular voivodships in 2015 (Table 1). Completion of the research induces to formulate several conclusions and observations of a more general nature.

1. In the regional research of complex phenomena, including research related to evaluation of pro-environmental activities, an important, invaluable role is played by multi-dimensional comparative analysis, fragments of which are presented in this thesis.
2. As a result of application of the concerned research apparatus, it has been determined that some differences occur in the level of activities for environmental protection undertaken by particular voivodships.
3. The degree of diversification of voivodships due to the discussed phenomenon should be assessed as relatively low [$I(Q_i) \cong 2$]. This opinion is confirmed in the results of the study on spatial distribution of pollution in Poland [Kukuła 2000]. In this case, the quotient of extreme values of the synthetic variable is at a significantly higher level, reaching the value of over 33.
4. In the set of 16 examined voivodships ordered due to the discussed complex phenomenon, a small their number (only 4 items) was qualified to the first group with high involvement in environmental protection activities. The remaining two groups, each containing 6 voivodships, represent an average and a low level of pro-environmental activities.
5. The obtained spatial distribution of the synthetic variable should be assessed negatively despite their relatively even scores in particular voivodships. This raises a question: is this relatively equalised level of pro-environmental activities in particular voivodships appropriate in confrontation with very large diversity in the degree of their pollution [Kukuła 2014a].
6. In order to obtaining proper proportions between the level of pro-environmental activities in voivodships and the degree of their pollution, we should, on the one hand, gradually eliminate the reasons for pollution emission, while on the other hand, increase efforts related to pro-environmental activities in voivodships which are the greatest polluters of the natural environment.
7. Implementation of this postulate will result in deepening of the degree of diversification of voivodships due to the undertaken pro-environmental activities, i.e. increase in the value of parameter $I(Q_i)$.

REFERENCES

Borys, T. (1978). Metody unormowania cech w statystycznych badaniach porównawczych, Przegląd Statystyczny, 25 (2), 227–239.

Hellwig, Z. (1968). Zastosowanie metody taksonomicznej do typologicznego podziału krajów ze względu na poziom ich rozwoju oraz zasoby i strukturę wykwalifikowanych kadr. Przegląd Statystyczny, 4, 307–326.

Kisielińska, J. (2016). Ranking państw UE ze względu na potencjalne zaspokojenie zapotrzebowania na produkty rolne z wykorzystywaniem porządkowania liniowego. Problemy Rolnictwa Światowego, 16 (3), 142–152.

Kukuła, K. (2000). Metoda unitaryzacji zerowanej. PWN, Warszawa.

Kukuła, K. (2014a). Regionalne zróżnicowanie stopnia zanieczyszczenia środowiska w Polsce a gospodarka odpadami. Wybrane Problemy Zarządzania Rozwojem Regionalnym, 15 (8), 183–198.

Kukuła, K. (2014b). Zero Unitarization Metod as a tool in Ranking Research. Economic Science for Rural Development, Jelgava, 36, 95–100.
Matczak, P. (2000). Problemy ekologiczne jako problemy społeczne. Wydawnictwo Uniwersytetu A. Mickiewicza, Poznań.
Nowak, E. (1990). Metody taksonomiczne w klasyfikacji obiektów społeczno-gospodarczych. PWE, Warszawa.
Pluta, W. (1977). Wielowymiarowa analiza porównawcza w badaniach ekonomicznych. PWE, Warszawa.
Strahl, D. (1990). Metody programowania rozwoju społeczno-gospodarczego. PWE, Warszawa.

DZIAŁALNOŚĆ PROEKOLOGICZNA W POLSCE W 2015 ROKU (STUDIUM REGIONALNE)

STRESZCZENIE

Autor artykułu stawia przed sobą dwa zadania. Pierwszym jest próba przedstawienia techniki budowy rankingu obiektów (tu województw) ze względu na poziom zjawiska złożonego, a w dalszej kolejności prezentacja metody podziału obiektów na grupy o zbliżonych wartościach zmiennej syntetycznej. Drugim celem jest ukazanie stanu działalności proekologicznej w Polsce w 2015 roku w układzie regionalnym. Do realizacji tego celu wyselekcjonowano zmienne diagnostyczne opisujące stan działalności na rzecz ochrony środowiska. Według merytorycznych oraz dostatecznych zmienności wybrano 11 cech diagnostycznych. Zmienne te stanowią podstawę wielokryterialnej oceny badanego zjawiska złożonego (działalność proekologiczna). Na podstawie opisanej procedury stworzono ranking województw ze względu na stan działań na rzecz środowiska w Polsce. Zbiór obiektów (województw) podzielono na 3 grupy: grupa I (G_1) województwa o wysokim, grupa II (G_2) województwa o przeciętnym i grupa III (G_3) o relatywnie niskim poziomie działalności proekologicznej. Proporcje ilościowe województw w poszczególnych grupach kształtują się następująco: $G_1 : G_2 : G_3$ jak 4 : 6 : 6.

Słowa kluczowe: ochrona środowiska, województwo, zmienna diagnostyczna, zmienna syntetyczna, ranking