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EQUIPMENT WITH SOME APPLIANCES AND FACILITIES OF ENVIRONMENTAL PROTECTION IN VILLAGES (SPACE STUDY – 2013)

Karol Kukuła
University of Agriculture in Krakow

Abstract. In the paper an attempt of assessment of equipment with some appliances and facilities of environmental protection in villages was made. The analysis was conducted taking into account division of country territory into voivodeships using methods of multi-dimensional comparative analysis. The final result of the study is voivodeships ranking and dividing voivodeships into three groups: of a high, average and low level of village environmentally friendly infrastructure. Attention was paid to relatively great span between the first group (group of the best equipment) and the third group – the worst in this respect.

Key words: ranking, object, diagnostics variable, synthetic variable, environmental protection

INTRODUCTION

Maintaining clean natural environment of the villages follows all-Poland environmentally friendly operations. It is a well-known fact that cleanliness of the environment constitutes national good that should be protected in rural areas as well. The efforts involve incurring expenses for appliances and facilities which are to provide all users with clean water, create separate places of storage of waste and rubbish and carry away impurities by subjecting them to filtration processes.

The main goal of the article is to assess the equipment of rural areas of different voivodeships in appliances and devices serving environmental purpose. Another objective is creation of the ranking arranging voivodeships from best equipped to the most poorly equipped with environmentally friendly rural infrastructure. The analysis presents the condition of the concerned phenomenon on 31 December 2013. This work constitutes a fragment of cycle of articles falling within the scope of issues of sustainable

Corresponding author: Karol Kukuła, Department of Econometrics and Statistics, University of Agriculture in Krakow, al. Mickiewicza 21, 31-120 Kraków, poland, e-mail: ksm@ur.krakow.pl

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development, relates to issues of contamination of the environment and ecological actions [Kukuła 2014a] and waste management [Kukuła 2014b].

It should be assumed that environmentally friendly appliances and facilities of rural areas constitute a complicated issue [Kukuła 2000] that can be described by means of not one but several characteristics (variables). These variables were observed in all voivodeships, making collective evaluation of environmentally friendly rural infrastructure possible. Application of appropriate tools of multi-dimensional comparative analysis creates an opportunity of determining the difference between the most poorly equipped voivodeships with those occupying the highest position in the ranking. It is worth mentioning that similar analysis at the level of poviats was conducted by Dolata [2008]. Her analysis focused on ecological infrastructure in poviats of Wielkopolskie Voivodeship proved substantial diversity between objects.

Statistical data enabling comparative tests of voivodeships with regard to ecological infrastructure of Polish rural areas come from publications of the Central Statistical Office of Poland titled Ochrona Środowiska [Environmental Protection]. Environment 2014.

MATERIAL AND METHOD

Obtaining the ranking of voivodeships (interchangeably called objects) is not easy and consists of certain activities that should be performed. Key task in the procedure of construction of the ranking is to prepare selection of diagnostic variables, namely variables typical of the examined phenomenon. Selected variables create X-matrix:

$$X = [x_{ij}] = \begin{bmatrix} X_{11} & X_{12} & \dots & X_{1s} \\ X_{21} & X_{22} & \dots & X_{2s} \\ \dots & \dots & \dots & \dots \\ X_{r1} & X_{r2} & \dots & X_{rs} \end{bmatrix} \qquad (1)$$

where: $i = 1, \dots, r$ (r – number of objects);
$j = 1, \dots, s$ (s – number of diagnostic variables).

Variability of features was defined by means of simple meter, being a quotient of extreme values of each of potential diagnostic variables:

$$I(X_j) = \frac{\max_i x_{ij}}{\min_i x_{ij}}, \quad \min_i x_{ij} > 0 \qquad (2)$$

It was assumed that variable X_j is qualified to diagnostic variables if:

$$I(X_j) > 2 \ (j = 1, \dots, s) \qquad (3)$$

From the perspective of ranking construction, specified in this way minimum level of variability of features seems to be sufficient.

Selected features have different sizes and usually different changes. For the purpose of standardization of their value and making them comparable, one of standardization procedures was used – method of zero unitarization. Possible applications and properties of this method were discussed in monograph [Kukuła 2000].

Diagnostic variables may be of various character, which results in influence on evaluation of complex phenomenon. If an increase of a features results in increased value of described phenomenon – these variables form a set of a positive variables (*S*). There exist such variables whose growth results in fall of value of complex phenomenon. These variables belong to a set of negative variables (*D*). Slightly less frequently (but it happens) we deal with variables that have optimum values. This may be one value or value interval. These variables form a set of nominants (*N*). The precursor in spatial research using multi-dimensional comparative analysis in Poland is Z. Hellwig. In his pioneer work [Hellwig 1968] introduced into subject literature a division of variables into positive variables and negative variables. The notion of nominants was introduced by T. Borys in 1978. In our research there are only features that are positive variables. Therefore, formula transforming original values of features into standardized features is as follows:

$$z_{ij} = \frac{X_{ij} - \min_i x_{ij}}{\max x_{ij} - \min_i x_{ij}} \qquad (X_j \in S) \tag{4}$$

provided that

$$Z_{ij} \in [0, 1] \tag{5}$$

Standardization of all features enables receiving synthetic variables (Q_i) characterizing the level of an examined phenomenon submitted in each of facilities. First, we accumulate values of regulated features for each object:

$$q_i = \sum_{j=1}^{s} z_{ij}, \qquad (i = 1, \ldots, r) \tag{6}$$

Successively we set the average value of regulated features and obtain synthetic variable (Q_i):

$$Q_i = \frac{1}{s}\sum_{j=1}^{s} z_{ij} \tag{7}$$

provided that $Q_i \in [0, 1]$

Synthetic variables constitute the basis for ranking construction. In ranking objects are ordered from the best to the worse.

After ordering facilities according to synthetic variable Q_i, they can be divided into any number of l groups smaller than *r* (the number of objects). In our study there are 16 objects (voivodeships), therefore division into 3 groups seems reasonable (l = 3). For this purpose, the following procedure should be used [Kukuła 2014c]:

1. Calculate range of synthetic variable $R(Q_i)$:

$$R(Q_i) = \max_i Q_i - \min_i Q_i \tag{8}$$

2. Identify the value (k) of division parameter:

$$k = \frac{R(Q_i)}{3} \tag{9}$$

3. Parameter value k is used for division of sets of objects into groups:
   - Group I (the highest level of complex phenomenon) – $Q_i \in (\max_i Q_i - k; \max_i Q_i]$;
   - Group II (medium level of complex phenomenon) – $Q_i \in (\max_i Q_i - 2k; \max_i Q_i - k]$;
   - Group III (low level of complex phenomenon) – $Q_i \in [\max_i Q_i - 3k; \max_i Q_i - 2k]$.

Presented procedure of objects division in generated ranking enables selecting three groups of voivodeships: of high, average and low level of ecological infrastructure.

SELECTION OF DIAGNOSTIC FEATURES

Selection of diagnostic variables for research on the equipment with appliances and facilities of environmental protection was conducted taking account three criteria:
- data availability;
- content usefulness;
- fulfillment of the requirement of the minimum the level of variability.

Set of features qualified as diagnostic variables contains six items. The six variables were recorded on 31 December 2013. The variables are positive variables:
- X_1 – capacity of collective waste water treatment facilities in m^3 per one agricultural holding;
- X_2 – number of individual waste water treatment facilities per 100,000 village inhabitants;
- X_3 – waste landfills-area in ha per 100,000 village inhabitants;
- X_4 – number of water treatment stations per 100,000 village inhabitants;
- X_5 – collective sewage network in km per 100,000 village inhabitants;
- X_6 – number of sewage connections to buildings in units per 100,000 village inhabitants.

All selected features fulfill condition of sufficient variability expressed with unevenness [$I(X_j) > 2$]. It is worth noting that the highest variability measured with measure (2) show the characteristics related to sewage treatment plants $I(X_1) = 30.35$ and $I(X_2) = 25.58$. The lowest variability is shown by the characteristics X_6 and X_5 [$(X_6) = 2.81$ and $I(X_5) = 6.56$]. These are: number of sewage connections to the buildings and the length of collective sewerage network in km (both variables adjusted for 100,000 of village inhabitants).

RESULTS

For the purpose of regulating diagnostic features included in the Table 1, zero unitarization was used. Owing to the fact that all selected variables are positive variables, the following formula (4) was used for standardization. Standardization results are presented in Table 2.

Table 1. Values of diagnostic variables related to environmental protection of rural environment (31.12.2013)

Specification		X_1	X_2	X_3	X_4	X_5	X_6
Poland		1.292	820	11.35	46	525	8.48
Voivodeships	Dolnośląskie	2.766	700	15.98	40	617	9.48
	Kujawsko-Pomorskie	1.144	2066	19.29	48	532	7.17
	Lubelskie	0.263	1546	12.36	41	280	4.83
	Lubuskie	5.554	590	9.48	101	479	6.87
	Łódzkie	0.584	1206	10.23	54	283	6.17
	Małopolskie	1.282	458	2.81	10	465	7.79
	Mazowieckie	0.748	981	6.74	40	322	6.80
	Opolskie	3.869	474	15.70	26	562	11.12
	Podkarpackie	0.732	81	4.04	20	986	13.57
	Podlaskie	0.183	2072	1232	59	326	5.52
	Pomorskie	2.630	352	20.07	85	780	11.49
	Śląskie	2.429	429	4.18	13	473	9.98
	Świętokrzyskie	0.074	734	3.44	12	528	7.90
	Warmińsko-mazurskie	1.768	511	13.91	101	751	7.10
	Wielkopolskie	3.276	828	18.58	60	477	9.61
	Zachodniopomorskie	2.827	415	35.76	162	915	10.40
Quotient of extreme values		30.350	25.580	12.726	16.200	3.521	2.810

Source: Own elaboration on the basis of Environmental Protection. Environment 2014, CSOoP Warsaw, 2014, 468–469.

Another action is aggregation of standardized diagnostic features. In aggregation the same weight for each of the characteristics was adopted. The substantiation of such approach is the lack of information enabling determining weights of different diagnostic variables. In aggregation the following formula was used (6), which leads to obtaining standardized diagnostic variables for each voivodeship (q_i). Synthetic variables Q_i are arithmetic average of regulated features of each of 16 voivodeships (template 7). Values variables q_i and Q_i was presented in Table 2. Values of synthetic variable Q_i are the grounds for construction of the ranking of voivodeships owing to the state of rural environmentally friendly infrastructure on 31 December 2013. This ranking along with the division of voivodeships into three groups is presented in Table 3.

Table 2. Standarized values of diagnostic variables

Voivodeship	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	q_{and}	Q_{and}
Dolnośląskie	0.491	0.311	0.400	0.197	0.478	0.532	2.409	0.402
Kujawsko-pomorskie	0.195	0.997	0.500	0.250	0.357	0.268	2.567	0.428
Lubelskie	0.034	0.736	0.290	0.204	0	0	1.264	0.211
Lubuskie	1	0.256	0.202	0.599	0.282	0.233	2.572	0.429
Łódzkie	0.093	0.565	0.225	0.289	0.004	0.153	1.329	0.222
Małopolskie	0.220	0.189	0	0	0.262	0.339	1.010	0.168
Mazowieckie	0.123	0.452	0.119	0.197	0.060	0.225	1.176	0.196
Opolskie	0.693	0.197	0.391	0.105	0.400	0.720	2.506	0.418
Podkarpackie	0.120	0	0.037	0.066	1	1	2.223	0.371
Podlaskie	0.020	1	0.289	0.322	0.065	0.079	1.775	0.296
Pomorskie	0.466	0.136	0.524	0.493	0.709	0.762	3.090	0.515
Śląskie	0.430	0.175	0.042	0.020	0.274	0.589	1.530	0.255
Świętokrzyskie	0	0.328	0.019	0.013	0.352	0.351	1.063	0.177
Warmińsko-mazurskie	0.309	0.216	0.337	0.599	0.668	0.260	2.389	0.398
Wielkopolskie	0.584	0.375	0.479	0.329	0.279	0.547	2.593	0.432
Zachodniopomorskie	0.502	0.168	1	1	0.901	0.637	4.208	0.701

Source: Own elaboration on the basis of data in Table 1.

Table 3. Ranking of voivodeships according to equipment with some appliances and facilities for environmental protection in 2013

Place in the ranking	Voivodeship	Q_{and}	Groups
1	Zachodniopomorskie	0.701	I (1 voivodeship)
2	Pomorskie	0.515	Group II (8 voivodeships) $\overline{Q}_{II} = 0.424$
3	Wielkopolska	0.432	
4	Lubuskie	0.429	
5	Kujawsko-Pomorskie	0.428	
6	Opolskie	0.418	
7	Dolnośląskie	0.402	
8	Warmińsko-mazurskie	0.398	
9	Podkarpackie	0.371	
10	Podlaskie	0.296	Group III (7 voivodeships) $\overline{Q}_{III} = 0.218$
11	Śląskie	0.255	
12	Łódzkie	0.222	
13	Lubelskie	0.211	
14	Mazowieckie	0.196	
15	Świętokrzyskie	0.177	
16	Małopolskie	0.168	
Quotient of extreme values of synthetic variable – I (Q_{and}) = 4.173			

Source: Own elaboration on the basis of Table 2.

Group I, the one with the best developed ecological infrastructure, comprised only one object – the Zachodniopomorskie Voivodeship. Comparison of synthetic variables suggests that the voivodeship dominates over the rest of voivodeships (see Table 3).

The most numerous group II includes eight voivodeships. These are the following voivodeships (in ranking order): Pomorskie, Wielkopolskie, Lubuskie, Kujawsko-pomorskie, Opolskie, Dolnośląskie, Warmińsko-mazurskie and Podkarpackie. These objects are characterized by average level of equipment of appliances and facilities of environmental protection.

Group III consists of objects of relatively low development of environmentally friendly infrastructure and it includes seven voivodeships. These are the following voivodeships: Podlaskie, Śląskie, Łódzkie, Lubelskie, Mazowieckie, Świętokrzyskie and Małopolskie. Voivodeships belonging to this group and especially those occupying the last two places in the ranking (Świętokrzyskie and Małopolskie) have significantly worse level of environmentally friendly infrastructure.

Better understanding of spatial setting of the phenomenon shall be provided by the map presented in Figure 1.

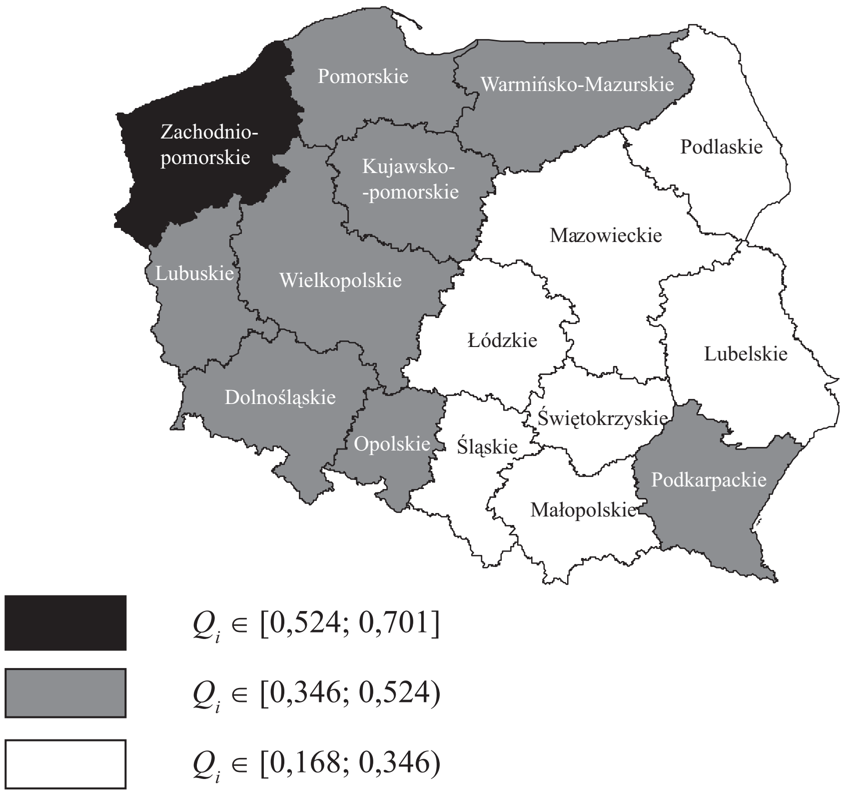

Fig. 1. Groups of voivodeships: breakdown by equipment with appliances and facilities for the rural environment protection on 31.12.2013

Source: Own elaboration on the basis of Table 3 and database of GUS (www.stat.gov.pl/bdl).

CONCLUSIONS

Completed study enables formulating several remarks and conclusions.

1. Equipment of the Polish village with appliances and facilities for environmental protection differs depending on voivodeships. Best equipped with appliances and facilities for rural environment protection are voivodeships located in the western and northern part of Poland. Rural areas of eastern, middle and southern part of Poland are relatively less effectively equipped with environmentally friendly infrastructure. The exception is the Podkarpackie Voivodeship, qualifying for a group of medium level of equipment of villages with appliances and facilities of environmental protection.
2. There are large differences between the voivodeships of Group I and objects of the end of the ranking [I (Q_i) = 4.173]. Condition of the examined infrastructure of the Zachodniopomorskie Voivodeship exceeds more than four times condition of infrastructure of Małopolskie (the last place in the ranking).
3. Łódź and Śląskie Voivodeships affiliation to last, group III of the worse equipment with environmentally friendly village infrastructure is surprising. It is worth mentioning the fact that listed voivodeships belong to major destroyers of the natural environment in Poland [Kukuła 2014b]. Śląskie Voivodeship has the first and Łódzkie Voivodeship the second place on the list of voivodeships most strongly polluting the environment.
4. Research proved existence of relatively deep differences between the voivodeships in terms of flow capacity of collective waste water treatment facilities and the number of individual sewage waste water treatment facilities (see Table 1). Voivodeships needing more numerous or more effective waste water treatment facilities are (starting from least effective): Świętokrzyskie, Podlaskie, Lubelskie, Łódzkie, Podkarpackie and Mazowieckie. Voivodeships poorly equipped with individual waste water treatment facilities are: Podkarpackie, Pomorskie, Zachodniopomorskie, Śląskie and Małopolskie.
5. Improvement in ecological infrastructure in rural areas will soon determine their development. It is worth emphasizing that analysis similar to the one presented in this article should be carried out both at the level of poviats as well as gminas in each voivodeship [Dolata 2008]. It shall enable identifying weak cells requiring corrective actions.
6. Zachodniopomorskie Voivodeship occupying the first position in the ranking is characterized by high level of all diagnostic features taken into account. All variables have standarization above 0.5 except for the variable of the number of individual waste water treatment facilities where standardization amounts 0.168 (see Table 2).
7. Małopolskie Voivodeship, ranked last, exhibits low level of all diagnostic features (their standardizations have values significantly below 0.5). In this voivodeship there is the worst situation with regard to waste landfills as well as the quantity of water treatment stations (see Table 2). The obtained results indicate problems to be solved in the future. These actions are in accordance with tasks set by UE with regard to eliminating excessive differences in levels of regions development in terms of their equipment in infrastructure of environmental protection.
8. The existing state of affairs has, to a large extent, its source in the period of the People's Republic of Poland (PRoP).

9. Tools offered by a multi-dimensional comparative analysis undoubtedly enrich the materials for regional research by enabling obtaining measurable and objective evaluations.

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STAN WYPOSAŻENIA WSI W OBIEKTY I URZĄDZENIA OCHRONY ŚRODOWISKA (STUDIUM PRZESTRZENNE – 2013 R.)

Streszczenie. Celem artykułu jest ukazanie aktualnego stanu wyposażenia wsi w infrastrukturę proekologiczną. Zebrane informacje sprowadzono do stanu porównywalności, stosując metodę unitaryzacji zerowanej. Unormowane zmienne pozwoliły otrzymać wartości zmiennej syntetycznej charakteryzujące każdy obiekt (województwo). Zmienne te są podstawą budowy rankingu województw przedstawiającego aktualną sytuację w zakresie przestrzennych zróżnicowań wyposażenia wsi w obiekty i urządzenia sprzyjające środowisku. Końcowym etapem badań jest podział obiektów na trzy grupy województwa: o wysokim, przeciętnym i niskim poziomie proekologicznego wyposażenia wsi.

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

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