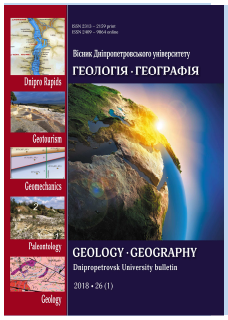

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Typization of administrative districts of Dnipropetrovsk region on the level of development of pre-school education (by methods of modeling of the trajectory of motion of sociogeosystems and cluster analysis)

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Abstract. The simulation of the trajectory of the development of the educational component of district sociogeosystems in a multidimensional normalized space on the example of the subsystem of preschool education (in six indicators) was conducted on average for 2008-2017. According to the results of simulation of the development trajectory of the subsystem of pre-school education of district sociogeosystems based on the analysis of the coherence of their development trajectories with the optimal trajectory and the coherence of the development trajectory between the district sociogeosystems, it was established that the trajectories of the movement of the Apostolovsky, Solonyansky and Verkhnodniprovsky districts were closest to the point of maximal development. The most distant from it were the trajectories of development of Vasylkivsky, Pavlogradsky, Petrykivskyi districts. The average indicators of the rejection of the path through the sociogeosystems of the districts of the Dnipropetrovsk region have been calculated, and it has been established that only nine districts of the region (Vasylkivsky, Dnipropetrovsk, Krynichansky, Nikopolsky, Novomoskovsk, Pavlohradsky, Pokrovsky, Synelnikovsky, Tomakivsky) have positive meanings, the other thirteen districts are negative, indicating the inconsistency in the educational component of district sociogeosystems of the Dnipropetrovsk region. The highest index of distance from the origin of the specified time interval has the Apostolovsky district. High rates are characteristic for Pokrovsky, Krivoy Rog, Solonyansky districts. Low rates have Vasylkivsky, Petrykivsky, Pavlogradsky areas that lag behind in the development of the educational system of preschool education from other administrative units of the region. It was clarified that the districts of the Dnipropetrovsk region have been unevenly developed. Most progressed in the Vasylkivsky district, a little behind him trajectories of growth of Petrikivsky, Tomakivsky and Yurievsky districts. The grouping of administrative regions of the Dnipropetrovsk region on the basis of cluster analysis allowed allocating five groups (clusters) of subsystems of pre-school education according to the similarity of their territorial organization.

Keywords: pre-school education, modeling of the trajectory of motion of sociogeosystems, cluster analysis.

Типізація адміністративних районів Дніпропетровської області за рівнем розвитку дошкільної освіти (за методами моделювання траєкторії руху соціогеосистем та кластерного аналізу)

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Анотація. Проведено моделювання траєкторії розвитку освітньої складової районних соціогеосистем у багатовимірному нормованому просторі на прикладі підсистеми дошкільної освіти (за шістьма показниками) в середньому за 2008 - 2017 року. За результатами моделювання траєкторії розвитку підсистеми дошкільної освіти районних соціогеосистем на основі аналізу узгодженості їх траєкторій розвитку з оптимальною траєкторією та узгодженості траєкторії розвитку між районними соціогеосистемами встановлено, що найближче до точки максимального розвитку опинились траєкторії руху Апостолівського, Солонянського та Верхньодніпровського районів. З'ясовано, що райони Дніпропетровського регіону пройшли неоднаковий шлях розвитку. Найбільше просунувся у прогресі Васильківський район, від нього дещо відстають траєкторії росту Петриківського, Томаківського та Юр'ївського районів. Групування адміністративних районів Дніпропетровської області на основі кластерного аналізу дозволило виділити п'ять груп (кластерів) підсистеми дошкільної освіти за подібністю їх територіальної організації.

Ключові слова: дошкільна освіта, моделювання траєкторії руху соціогеосистем, кластерний аналіз.

Introduction. Pre-school education is a compulsory primary component of the system of continuing education in Ukraine and represents a holistic process aimed at ensuring the diverse development of a child of preschool age in accordance with her abilities, individual, mental and physical characteristics; the formation of a child's preschool age moral standards, the acquisition of her social life's experience.

The subsystem of pre-school education is regulated by the Ukrainian legislation, which is based on the Constitution of Ukraine, the Laws of Ukraine "On Education", "On Pre-School Education", "On Child Protection", the Convention "On the Rights of the Child", the resolution on the state national program "Education (Ukraine XXI Century)", taking into account the norms of the Family Code of Ukraine.

The subsystem of pre-school education in Ukraine is: pre-school educational institutions regardless of subordination, types and ownership; scientific and methodological institutions; educational authorities; education and upbringing in the family. Preschools include nurseries, nurseries, kindergartens of the family, combined, compensating type (special and sanatorium), educational complexes, children's homes, orphanages of family and boarding, children's development centers, etc.

For a full-fledged development of the younger generation in Dnipropetrovsk region a wide network of pre-school educational institutions of various types, profiles and forms of ownership functions.

Studies of the regional educational complex in Ukraine appeared at the turn of the XX-XXI centuries and represented by the works of Stec'kyj (1999), Shuba (1999), Flinta (2005), Mel'nychenko (2005), Trusij, (2008), Virchenko (2010), Zajachuk (2011), Horozhankina (2011), Pankrat'jeva (2014) and others. However, existing research on the development of pre-school education is highly specialized; therefore the actual issues of the Dnipropetrovsk region today are typifying its administrative districts by the level of development of this subsystem of education.

In accordance with the definite topicality of the problem, the purpose of this work is to study the relationship between the components of the preschool educational system and the establishment of their influence on the spatial organization of preschool educational institutions of Dnipropetrovsk region.

Materials and methods of study. Basic foundation for modeling trajectory sociogeosystems in normalized multidimensional features space is the implementation of linear scaling of quantitative indicators of regional sociogeosystems (Njemec', 2009) and calculation parameters directions of motion and linear motion characteristics sociogeosystems (L. Njemec', Olijnyk & K. Njemec', 2003).

In order to model the trajectory of development of the educational component of district sociogeosystems of the Dnipropetrovsk region, we have chosen such a subsystem of the regional educational system as pre-school education.

K. Njemec' (2009) notes that the trajectory of motion of any object is determined by two sets of indicators - the direction of motion and the linear characteristics of the object traveled over a certain period of time. The first set of trajectory indicators includes the cosines of the angles formed by the segment of the trajectory of the given object with the trajectories of other objects, or certain specific directions. The second set of indicators is represented by various linear characteristics of the trajectory - the distances in the multidimensional space that characterize the path traversed by the object for a certain period of time, or the removal of the current point of the trajectory (at the given time) from the characteristic points of the space - the origin of the coordinates, the middle point of the sociogeosystem or the point of maximum development. Depending on the purpose of our study, the following linear values of the trajectory were determined (K. Njemec', O.Njemec', 2008; K. Njemec', 2009; L. Njemec', 2005; L. Njemec', Olijnyk & K. Njemec', 2003.):

- the way passed by the sociogeosystem in a multidimensional space (ΔL), - is defined as the Euclidean distance between the points of the trajectory at adjacent points of time and is a dynamic characteristic of the trajectory, because its length indicates the intensity of the movement of the sociogeosystem;

- distance from the current point trajectory of the zero point (L0), which is a measure of the efficiency of motion sociogeosystem - more effective sociogeosystem for equal period of time more far removed from the starting position; performance computing trajectories current point distance from the origin (L0) reflect summarized sociogeosystem move relative starting positions and characterize the effectiveness of its cumulative traffic for each settlement time; in the ideal case, when the sociogeosystem develops progressively and stably, the distance L0 must increase over time; the absolute value of L0 also characterizes the intensity of the motion of sociogeosystems in a multidimensional normalized space;

- distance from the current point of the trajectory to the end point (maximum development point) L1 characterizes the efficiency of the motion of the sociogeosystem; a more effective sociogeosystem will reach or be close to the highest; if the development of the sociogeosystem is planned, then the approach of the development of the current point to the point of maximum growth should decrease;

- the difference in the path remaining to reach the point of maximum development (L1), and the traversed path (L0), which gives an idea of the pace of movement of the sociogeosystem in a multidimensional space - a decrease in this figure indicates a faster movement of the sociogeosystem;

- the ratio L0 / L1, which in the normed space is also a relative assessment of the effectiveness of the sociogeosystem, since the growth of this indicator indicates a more rapid progress of this sociogeosystem.

Ratio was measured by linear scaling for the whole period under study. The obtained scales of all indicators varied in the range from 0 to 1.

The method of cluster analysis allowed forming homogeneous (uniform) educational facilities groups (clusters). The objects in the group are relatively similar in terms of the studied indicators and differ from objects in other groups.

The method of cluster analysis consists in forming an initial matrix of distances between clusters. The cluster classification is carried out according to the standardized values of the input indicators. Standardization of variables ensures the comparability of all indicators irrespective of their units of measure, since the input data reflects various properties of objects and are not comparable.

In order to assess the similarity element, a special measure is used - the distance between the administrative districts. This distance is based on the normalized values of all indicators and determines the degree of average deviation between them in the objects of clusterization. The matrix of the initial actual values of the indicators turns into a matrix of normalized indicators. Normalized values are calculated according to the formula (Virchenko, 2010):

$$\mathbf{Y_{st\ ij}} = \frac{\mathbf{Y_{ij}} - \overline{\mathbf{Y}}_\mathbf{i}}{\mathbf{S_{yi}}} \qquad (1),$$

Where $\mathbf{Y_{st\ ij}}$ is the normalized value of the *i-th* indicator in the *j-th* region; $\mathbf{Y_{ij}}$ - actual value of the *i-th* indicator of *j-th* region; $\overline{\mathbf{Y}}_\mathbf{i}$ - the average value of the *i-th* indicator; $\mathbf{S_{yi}}$ is the mean square deviation of *Yi-th* indicator.

The mean square deviation is determined by the formula [1]:

$$\mathbf{S_{yi}} = \sqrt{\frac{\sum_{j=1}^{n}(Y_{ji} - \overline{Y}_i)^2}{n-1}} \qquad (2),$$

On the basis of a matrix of normalized values of indicators, intercluster distances are calculated using the Euclidean distance formula [22]:

$$\mathbf{L_{jk}^2} = \sum_{i=1}^{m}(\mathbf{Y_{st\ ij}} - \mathbf{Y_{st\ ik}}) \qquad (3),$$

Where $\mathbf{L_{jk}^2}$ is the distance between the objects *j* and *k*; $\mathbf{Y_{st\ ij}}$ is the normalized value of the *i-th* index of the *j-th* region, $\mathbf{Y_{st\ ik}}$ is the normalized value of the *i-th* index of the *k* region.

It should be noted that the optimization of cluster structures is based on the matrix of Euclidean distances.

Results and their analysis. It is necessary to draw attention to the fact that the statistical indicators of the regional center - the city of Dnipropetrovsk (renamed to the city of Dnipro in 2016) and the cities of regional subordination (Vilnogirsk, Dniprodzerzhinsk (renamed to the city of Kamianske in 2016), Zhovti Vody, Krivoy Rig, Marganets, Nikopol, Novomoskovsk, Ordzhonikidze, Pavlograd, Pershotravensk, Sinelnikovo, Ternivka) significantly exceed the corresponding indicators in rural areas due to special investment conditions, therefore, to preserve the homogeneity of output data their rational use, the following analysis was carried out without taking into account the indicators of the regional center and cities of regional subordination, and indicators at district centers and cities combined with data in the regions into a single array of information.

For analysis of the subsystem of pre-school education in the Dnipropetrovsk region, six indicators have been selected reflecting its development for the period 2008 / 09-2016 / 17 academic years: number of institutions; the number of children in them; the load of permanent pre-school educational institutions per 100 places; Ukrainian language instruction in pre-school educational institutions; coverage of children by pre-school education; the density of pre-school educational institutions per 1 km^2.

The cosines of the corners of the ray trajectories relative to the optimal trajectory show the coherence of the district trajectories in the direction with the optimal, the deviation of the regional indicators from the average across the whole population of the regions reflects which of the areas is closer to the optimal trajectory (Table 1).

The data in Table 1 highlights the small values of cosines, which indicates significant deviation of the regional trajectories from the optimal (L. Njemec', 2003).

Taking into account the average cosine of the angle between the trajectories closest to the optimal trajectory was Tomakivsky, Pyatihatsky, Vasylkivsky, Krynichansky districts, and the most distant ones were Verkhnodniprovsky, Apostolovsky, Sofievsky, Magdalinivsky districts. 15 districts of the Dnipropetrovsk region have positive deviations from the average cosine.

Table 1 Coherence of trajectories of development of subsystem of preschool education of district sociogeosystems of Dnipropetrovsk region with optimal trajectory

Areas	Cosine of the angle between trajectories						
	2008-2013	**2013-2014**	**2014-2015**	**2015-2016**	**2016-2017**	**Average**	**Deviation**
Apostolovsky	0,108	-0,408	-0,176	-0,576	-0,520	-0,314	-0,352
Vasylkivsky	0,089	0,408	0,657	0,408	-0,352	0,242	0,204
Verkhnodniprovsky	-0,664	-0,607	-0,384	-0,516	-0,342	-0,503	-0,540
Dniprovsky	-0,226	-0,030	0,357	0,648	-0,503	0,049	0,012
Krivoy Rog	-0,029	0,408	-0,112	0,183	-0,057	0,079	0,041
Krynichansky	0,577	0,689	0,450	-0,408	-0,217	0,218	0,181
Magdalinivsky	0,195	0,694	-0,240	-0,510	-0,408	-0,054	-0,091
Mezhivskyy	0,080	-0,408	0,772	-0,326	0,098	0,043	0,006
Nikopolsky	0,264	0,886	-0,408	-0,255	-0,106	0,076	0,038
Novomoskovsk	-0,809	0,680	0,766	0,292	-0,459	0,094	0,056
Pavlogradsky	0,333	-0,577	0,069	0,337	0,347	0,102	0,064
Petrykivsky	0,571	0,560	-0,408	-0,408	-0,375	-0,012	-0,050
Petropavlivsky	-0,162	0,408	0,662	0,408	-0,587	0,146	0,108
Pokrovsky	-0,860	0,408	0,418	0,690	-0,400	0,051	0,014
Pyatihatsky	0,228	0,566	0,408	0,408	-0,362	0,250	0,212
Synelnikovsky	-0,205	0,566	-0,525	0,548	-0,069	0,063	0,025
Solonyansky	0,170	-0,408	0,476	0,060	-0,305	-0,001	-0,039
Sofievsky	-0,402	0,408	-0,408	0,408	-0,586	-0,116	-0,154
Tomakivsky	0,505	0,408	0,727	0,408	-0,428	0,324	0,286
Tsarichansky	0,595	-0,408	0,525	-0,133	-0,264	0,063	0,025
Shirokivsky	0,366	0,577	-0,814	0,133	-0,417	-0,031	-0,069
Yurievsky	0,598	-0,132	0,408	0	-0,575	0,060	0,022

The average values of the sociogeosystem pathway for the period 2008-2017, presented in Table 2, show that the fastest development of the preschool subsystem of the regional sociogeosystem is characteristic of Novomoskovsk, Vasylkivsky and Pavlogradsky districts of the Dnipropetrovsk region. The slowest rate of movement was observed in the Sofievsky, Krivoy Rog and Tsarichansky districts (Fig. 1). It should be noted that, in general, the indicators presented indicate a different intensity of the movement of district sociogeosystems in a normalized multidimensional space, which can be interpreted as a difference in the dynamics of socio-economic development of the districts of the Dnipropetrovsk region (K. Njemec', O. Njemec', 2008).

The average indicators of the deviation of the way (ΔL) passed by sociogeosystems of the districts of the Dnipropetrovsk region for the period of 2008-2017 in the multidimensional normalized space are characterized by the pace and directions of their development. The results of the analysis of the calculations show that only nine areas of the region (Vasylkivsky, Dniprovsky, Krynichansky, Nikopolsky, Novomoskovsk, Pavlogradsky, Pokrovsky, Synelnikovsky, Tomakivsky) have positive meanings, while the remaining thirteen districts are negative, indicating inconsistency in the development of the educational component district sociogeosystems of Dnipropetrovsk region. The highest negative values of the deviation from the average motion are Krivoy Rog and Tsarichansky districts.

Table 2 Average linear characteristics of trajectories of development of subsystem of preschool education of district sociogeosystems of Dnipropetrovsk region for the period of 2008-2017.

Areas	The way passed (ΔL)		Distance to 0		Distance to 1		Correlation	
	way	deviation	**L0**	deviation	**L1**	deviation	**L0+L1**	**L0/L1**
Apostolovsky	0,156	-0,084	1,857	0,373	0,797	-0,462	2,654	2,341
Vasylkivsky	0,393	0,153	1,308	-0,176	1,909	0,650	3,218	0,686
Verkhnodniprovsky	0,238	-0,001	1,583	0,099	0,944	-0,315	2,527	1,730
Dniprovsky	0,333	0,094	1,502	0,018	1,092	-0,168	2,594	1,383
Krivoy Rog	0,133	-0,107	1,706	0,221	0,965	-0,294	2,671	1,768
Krynichansky	0,310	0,070	1,653	0,169	1,050	-0,209	2,703	1,609
Magdalinivsky	0,175	-0,065	1,447	-0,037	1,303	0,043	2,749	1,114
Mezhivskyy	0,185	-0,055	1,503	0,019	1,276	0,016	2,778	1,179
Nikopolsky	0,296	0,057	1,419	-0,065	1,254	-0,006	2,673	1,150
Novomoskovsk	0,396	0,156	1,413	-0,071	1,188	-0,071	2,601	1,211
Pavlogradsky	0,339	0,099	0,726	-0,758	1,855	0,595	2,580	0,393
Petrykivsky	0,224	-0,016	1,293	-0,191	1,638	0,379	2,931	0,794
Petropavlivsky	0,213	-0,026	1,574	0,089	1,158	-0,102	2,731	1,368

Pokrovsky	0,261	0,021	1,736	0,252	1,030	-0,230	2,766	1,702
Pyatihatsky	0,216	-0,024	1,690	0,206	0,998	-0,262	2,688	1,707
Synelnikovsky	0,308	0,068	1,517	0,033	1,255	-0,004	2,772	1,211
Solonyansky	0,154	-0,086	1,705	0,221	0,942	-0,317	2,648	1,812
Sofievsky	0,152	-0,088	1,457	-0,027	1,304	0,044	2,761	1,124
Tomakivsky	0,243	0,003	1,333	-0,152	1,539	0,279	2,871	0,877
Tsarichansky	0,128	-0,112	1,472	-0,012	1,300	0,040	2,772	1,137
Shirokivsky	0,189	-0,050	1,315	-0,170	1,497	0,237	2,811	0,882
Yurievsky	0,231	-0,008	1,443	-0,041	1,416	0,157	2,859	1,034

It is necessary to pay attention to the fact that the highest index of distance from the origin for the specified period of time (Table 2) has the Apostolovsky district. High rates are characteristic for Pokrovsky, Krivoy Rog, Solonyansky districts (Fig. 2). Low rates have Vasilkovsky, Petrykivsky, Pavlogradsky areas that lag behind in the development of the educational system of pre-school education from other administrative units of the region.

The trajectories of the Apostolovsky, Solonyansky and Verkhnodniprovsky districts were closest to the point of maximum development. The most distant from it were the trajectories of development of Vasylkivsky, Pavlogradsky, Petrykivsky districts (Fig. 3).

The lowest minimum values of this indicator testify to the higher efficiency of the development of the sociogeosystem. The highest minimum values are observed for the Apostolovsky, Solonyansky and Verkhnodniprovsky districts (Table 2).

The smallest indicators of the effectiveness of the development of the subsystem of pre-school education of district sociogeosystems are characterized by high positive values of the deviation of the approach to the point of maximum growth from the average (K. Njemec', 2009), which demonstrate Vasylkivsky, Pavlogradsky, Petrykivsky districts, which are the least developed from other regions in development.

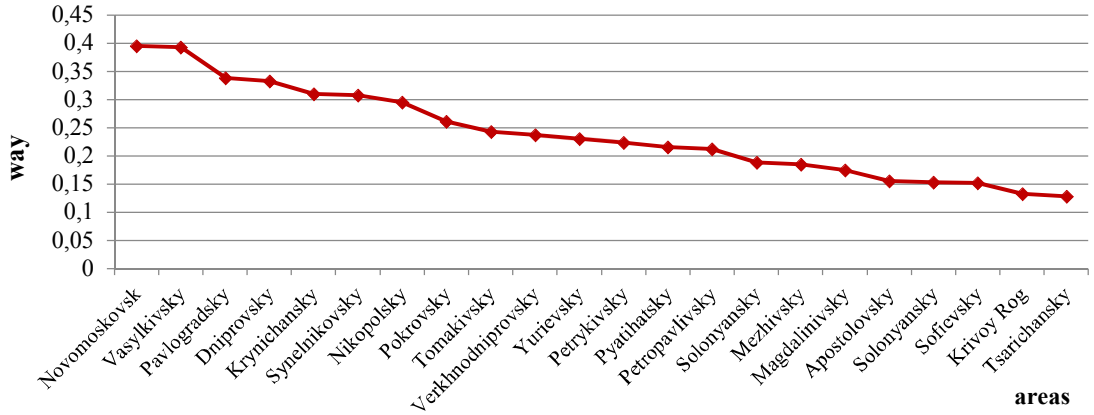

Fig. 1 Ranking subsystem of pre-school education of district sociogeosystems of Dnipropetrovs'k region by their way

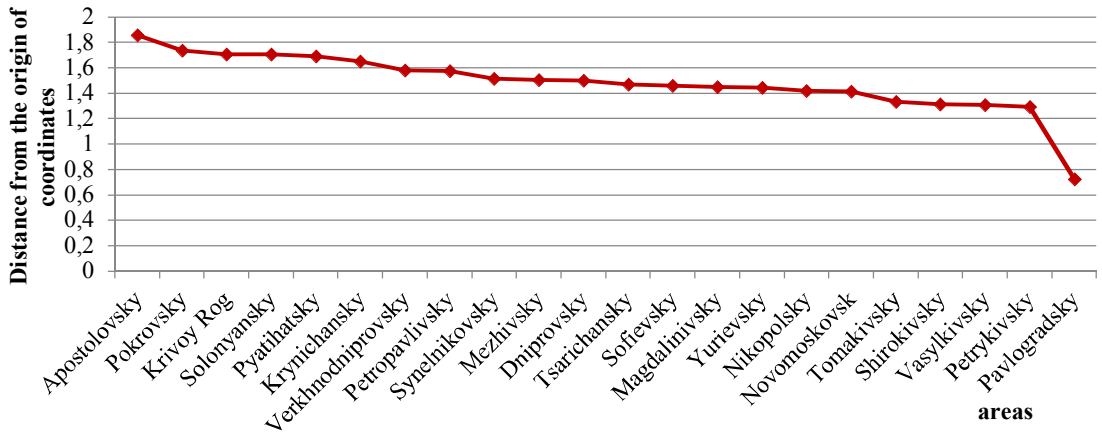

Fig. 2 Ranking subsystem of pre-school education of district sociogeosystems of Dnipropetrovsk region on the indicator of the distance of the current point of the trajectory from the origin of coordinates

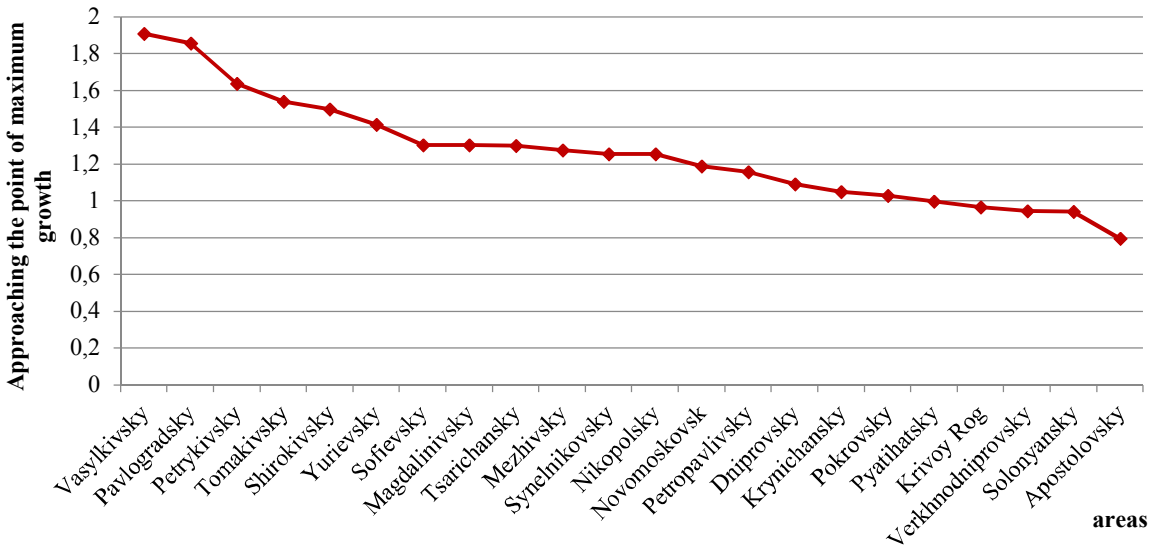

Fig. 3 Ranking subsystem of pre-school education of district sociogeosystems of Dnipropetrovsk region on the indicator of approaching the current point of the development trajectory to the point of maximum growth

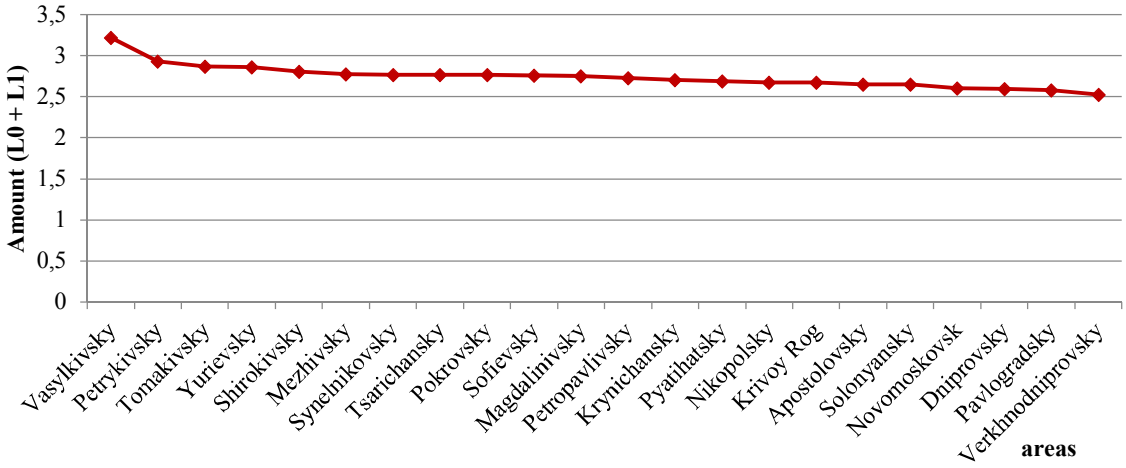

Fig. 4 Ranking subsystem of preschool education of district sociogeosystems of the Dnipropetrovsk region by the indicator of the amount of distances from the origin to the point of maximum growth (L0 + L1)

During the studied period, Vasylkivsky district has been the most advanced in the development, and some of it lags behind the growth trajectories of Petrykivsky, Tomakivsky and Yurievsky districts (Fig. 4). The lowest figures for the amount of distances from the origin to the point of maximum growth are Dniprovsky, Pavlogradsky, Verkhnedniprovsky districts, which confirms the low level of advance subsystems of pre-school education of district sociogeosystems of these administrative-territorial units.

According to the ratio of the distance between the current point of the development of rayon sociogeosystems of the Dnipropetrovsk region from the origin of the coordinates and the approach to the point of maximum growth (L0 / L1), the Apostolovsky, Solonyansky, and Krivoy Rog districts occupy the three leaders (Fig. 5).

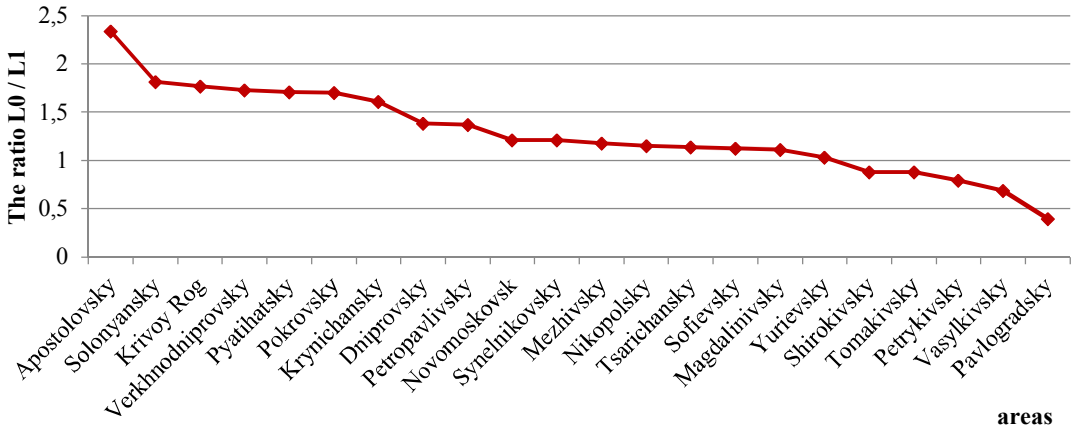

Fig. 5 Ranking subsystem of pre-school education of district sociogeosystems of Dnipropetrovsk region by average value of the distance ratio from the origin and maximum growth point (L0 / L1)

Low performance indicators are characteristic for Vasylkivsky, Petrykivsky, Pavlogradsky areas. The distribution of the educational component of district sociogeosystems of the Dnipropetrovsk region allowed to group the districts into four groups according to the criterion of progress in progress for the period of 2008-2017 (Fig. 6): low (3 districts), medium (8 districts), sufficient (7 districts), high (4 districts).

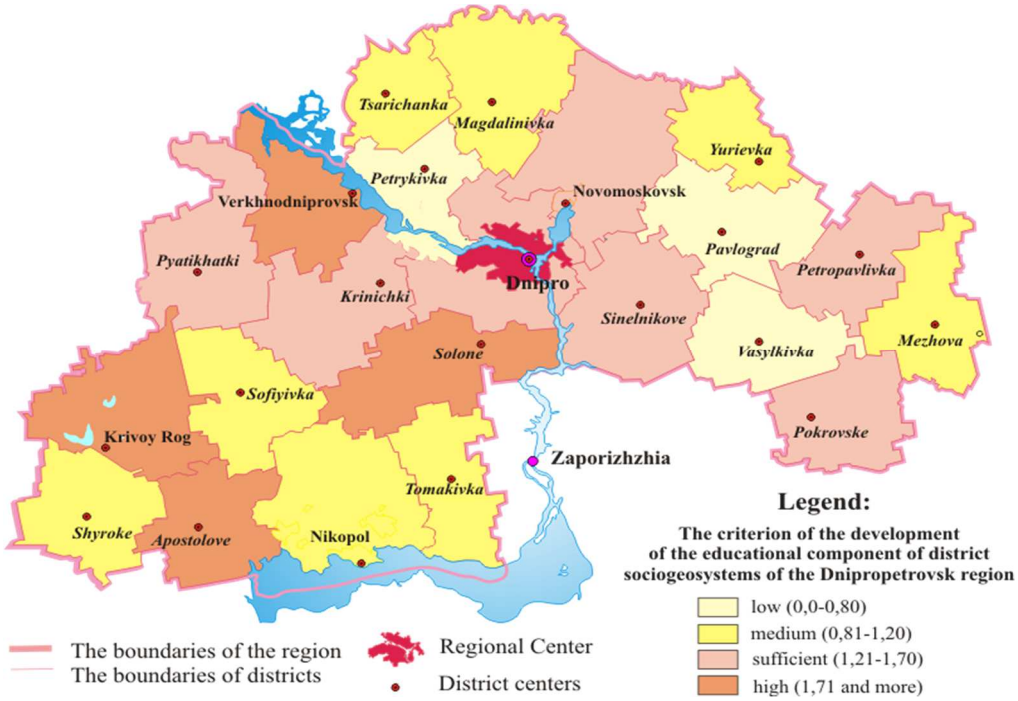

Fig. 6 Grouping of districts of Dnipropetrovsk region on the criterion of progress in the progress of the subsystem of preschool education (without cities of regional subordination)

According to six indicators of the subsystem of pre-school education, the cluster analysis was carried out and the matrix of connections was calculated that includes the frequency of the arrival of areas in the group for the period of 2008-2017. The results of cluster analysis allowed allocating five groups (clusters) of development of administrative-territorial units of the area. Taking into account the fact that cluster analysis is a hierarchical classification method, in four groups it became possible to allocate subgroups (subclusters) of administrative districts of Dnipropetrovsk region, which demonstrates the dendrogram in Fig. 7 and table 3.

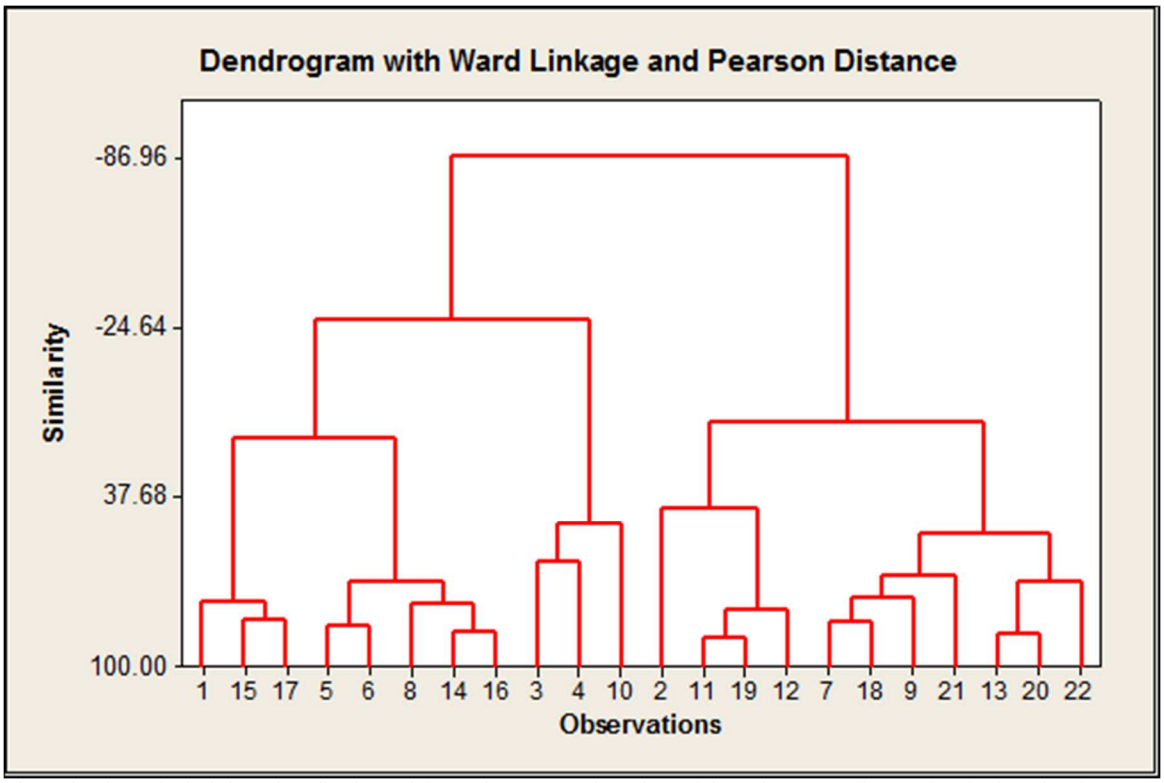

Fig. 7 Clusterization of administrative districts of the Dnipropetrovsk region of the subsystem of pre-school education by 2017

Table 3 Grouping of districts of Dnipropetrovsk region on the level of development of the subsystem of pre-school education by results of cluster analysis by 2017

Group	Subgroup	District number	Areas
First	1	1	Apostolovsky
		15	Pyatihatsky
		17	Solonyansky
	2	5	Krivoy Rog
		6	Krynichansky
	3	8	Mezhivsky
		14	Pokrovsky
		16	Synelnikovsky
Second	1	3	Verkhnodniprovsky
		4	Dniprovsky
	2	10	Novomoskovsk
Third	1	2	Vasylkivsky
	2	11	Pavlogradsky
		19	Tomakivsky
		12	Petrykivsky
Fourth	1	7	Magdalinivsky
		18	Sofievsky
		9	Nikopolsky
		21	Shirokivsky
Fifth	1	13	Petropavlivsky
		20	Tsarichansky
	2	22	Yurievsky

Conclusions. According to the results of the study, the following conclusions were formulated.

1. Modeling of the trajectory of development of the educational component of district sociogeosystems in multidimensional normalized space on the example of the subsystem of pre-school education (in six indicators) was conducted on average for 2008-2017.

According to the results of simulation of the development trajectory of the subsystem of pre-school education of district sociogeosystems based on the analysis of the coherence of their development trajectories with the optimal trajectory and the coherence of the development trajectory between the district sociogeosystems, it was established that the trajectories of the movement of the Apostolovsky,

Solonyansky and Verkhnodniprovsky districts were closest to the point of maximal development.

2. It was clarified that in the period of 2008-2017 the districts of the Dnipropetrovsk region have been unevenly developed. Most progressed in the district, a little behind him trajectories of growth of Petriksvsky, Tomakivsky and Yurievsky districts.

3. The grouping of administrative regions of the Dnipropetrovsk region on the basis of cluster analysis allowed allocating five groups (clusters) of subsystems of pre-school education according to the similarity of their territorial organization.

We can argue that at the present stage there is no single consistent trend in the development of the subsystem of pre-school education in the districts of the Dnipropetrovsk region, the reasons for which may be an imperfect approach and inadequate experience in developing an integrated strategy for the functioning of these subsystems of education, the heterogeneous socio-economic development of the districts of the region. All this requires considerable attention from the regional authorities.

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