Konstantin Niemets, Katerina Segida, Taras Pogrebskyi, Irina Barilo

V. N. Karazin Kharkiv National University, The Department of Socio-Economical Geography, Svobody sq. 4, 61022 Kharkov, Ukraine; e-mail: kon.nemets@yandex.ru; kateryna_segida@bk.ru; tarastimo04@mail.ru; irina.barilo@@mail.ru

SPATIAL AND STATISTICAL ANALYSIS OF SETTLING IN THE REGION (ON EXAMPLE OF POLTAVA REGION, UKRAINE)

Niemiec K., Segida K., Pogrebski T., Bariło I. **Przestrzenna analiza statystyczna rozmieszczenia ludności w regionie (na przykładzie obwodu połtawskiego)**. Przedstawiono podstawy metodyczne statystycznej analizy przestrzennej rozmieszczenia ludności w obwodzie. Na podstawie tej metodyki określono czynniki wpływające na rozmieszczenie ludności w regionie. Obliczono podstawowe wskaźniki: gęstość zaludnienia, współczynnik koncentracji ludności, centra rozmieszczenia ludności: średnie arytmetyczne, medialne, modalne, ważone, skośność rozkładu przestrzennego. Określono przestrzenne cechy rozmieszczenia ludności w obwodzie połtawskim oraz związki przyczynowo-skutkowe ze społeczno-ekonomicznym rozwojem regionu.

Немец К., Сегида К., Погребский Т., Барило И. **Пространственно-статистический анализ расселения населения региона (на примере Полтавской области Украины).** В статье представлены методические основы пространственно-статистического анализа расселения населения региона. По приведенной методике определены особенности расселения населения Полтавской области. Определены факторы влияния на расселение населения региона. Рассчитаны основные показатели расселения населения – плотность, индекс концентрации населения, центры распределения: средний арифметический, медиальный, модальный, тяжести; скошенность пространственного расселения населения. Определены территориальные особенности расселения населения Полтавской области и причинно-следственные связи с социально-экономическим развитием региона.

Key words: region, settlement, population density, an index of population concentration, the main parameters of the spatial distribution of the population
Słowa kluczowe: region, rozmieszczenie ludności, gęstość zaludnienia, indeks koncentracji ludności, centra rozmieszczenia ludności
Ключевые слова: регион, расселения населения, плотность населения, индекс концентрации населения, центры распределения населения

Abstract

The article presents the methodological basis of statistical analysis of spatial settlement in the region. According to the above method were defined the features of population settlement in Poltava region. The factors of influence on the settlement of the region's population were identified. Calculated the main indicators of population settlement – population density; an index of population concentration; the main parameters of the spatial distribution of the population: the arithmetic, median and modal centers; skewness of the spatial distribution of the population. Territorial characteristics of population settlement of Poltava region and cause-and-effect relationship with the socio-economic development of the region were defined.

INTRODUCTION

Nowadays the researchers focuses special attention on the characteristics of population differentiation of certain social and economic processes in the territorial and temporal aspects. Well known, that the resettlement of the population is the result of a historical process of settling the territory that is under the influence of several factors: natural, social, economic, political, which have a significant impact on the features of the settlement and placement of settlements, their relationship and so on. At the same time, an existing settlement system, as a form of organization of the population, determine the features of livelihoods of the population, socio-geographical process and so on. The population as a consumer has great influence on the development of industries that provide needs in food and industrial goods and services, ultimately determine the conditions of domestic demand and more. The study of population settlement is the subject-object field of human geography, or it's separate branch – the geography of population and attention is paid on the spatial distribution of individual populations or placement of individual popula-

tions on the territory of a region (district). An identification of the major spatial and statistical characteristics of the distribution of population in the territory is often performed using mathematical and statistical methods.

To identify local features of resettlement of the population of the region was analyzed Poltava region. System resettlement of the region is fairly typical for central regions of Ukraine and the country as a whole. Also, the region has high proportion of urban population, a large number of villages and sophisticated demographic conditions – a significant reduction of the population because of aging and its migration. In general, these processes are common to all regions of Ukraine, but Poltava region is an example of the similarity of the relevant indicators to national averages.

The aim of this work is spatial and statistical analysis of population settlement in the region of Ukraine – Poltava region. The research performed the following tasks: general characteristics of population resettlement in the region, characteristic of its density and concentration, determination of spatial and statistical features of the distribution of population by territory by calculating the arithmetic mean, median and modal centers and center of gravity, determination of total and scattering distance and spatial distribution of bevelling population, analysis of the results in the calculations.

RESEARCH METHODOLOGY

The most common measure used to determine the characteristics of the distribution of population is its density. *Population density* – the main unit of population distribution, reflects the average population living on 1 km²; calculated by dividing the population of the administrative unit to the area of the territory (SEGIDA, 2013).

To determine the degree of uniformity of population settlement in the region we used *an index of population concentration*, which shows how the population is distributed in relation to the total population of the territory. An index of population concentration in a particular area is calculated as the difference in particle size and population of the district (KRAVTSOVA, 2007).

The main parameters of the spatial distribution of the population are the arithmetic, median and modal centers. *Arithmetic center* is a measure of the central point of the spatial distribution of the population. It is measured by using of two coordinates **x** and **y**, which form straight lines that intersect at the arithmetic center of the region. To determine the *arithmetic center*, the massive numbers of distances (the length

of the region) is multiplied by the population of the districts and divided by the population of the entire region (NIEMETS et al., 2014).

The *median center* of the spatial distribution is similar to the median in linear statistics, which can be regarded as the position of the point which divides the population into two equal parts by latitude and longitude. The median center of the spatial distribution – a point on the surface, the sum of the distances from which all other units of the population is minimal (NIEMETS et al., 2014).

Modal center can be defined as the bigger point on the surface area distribution. This is one of the most important indicators of spatial distribution, which determines the location of the largest concentrations of population.

To identify and analyze the location and dispersion of the population we determined the *center of gravity* of the geographical phenomenon – a point with the average coordinates of the geographical coordinates of the centers of individual territorial units of area – weighted quantity (mass) of any signs of these areas (KRAVTSOVA, 2007).

To determine the *skewness of the spatial distribution of the population* of the region we used the nearest neighborhood analysis. This parameter is based on the determination of the distance of each point to the nearest neighbor populations. It is the arithmetic mean of the actual distance between each member of the population and its nearest neighbor (SEGIDA, 2013).

THE RESULTS OF RESEARCH

The organization of the population as a territorial organization of social production is directly linked to the settlement system of the region. Administrative division of Poltava region includes 25 districts, 15 cities [5 of them – cities of regional subordination (Komsomolsk, Kremenchug, Lubny, Myrhorod, Poltava) and 10 of them district-level towns)], 21 urban settlements and 1826 settlements of rural type. The administrative center – the city of Poltava (*Poltavs'-ka oblast'*..., 1998; BULAVA, 2004).

Therefore, the settlement system of Poltava region represented by settlements with different number of people (fig. 1). Total area of the region is moderately populated. In the region, like in Ukraine as whole, there is a tendency of reducing the number of villages. At the same time, Poltava region ranks the second place in Ukraine by the number of rural settlements – 1826, second only to Lviv region (1850 villages). The level of urbanization in the region is 62%, respectively, the urban population – 898 thousand people, rural – 557 thousand people.
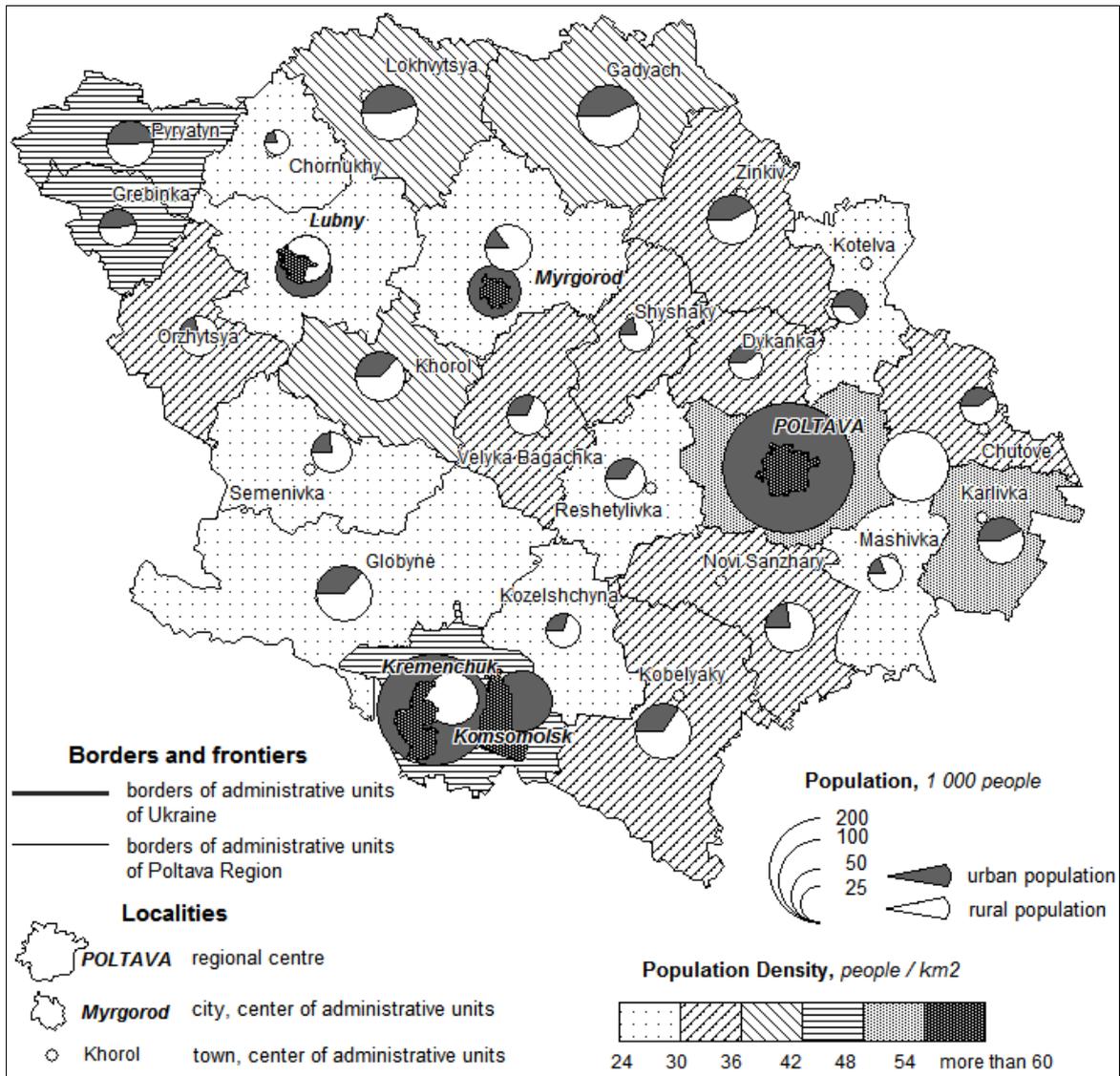
Fig. 1. The population density of Poltava region on 01.01.2014 (according to *Oficiynyi sayt Golovnogo...*)

Rys. 1. Gęstość zaludnienia obwodu połtawskiego wg stanu na dzień 1.01.2014 (wg *Oficiynyi sayt Golovnogo...*)

Population density is calculated by the following formula (*Oficiynyi sayt Golovnogo...; Oficiynyi sayt Derzhavnoyi...*):

$$D = \frac{P}{S} \qquad (1)$$

where: P – population,

S – area of the region (district).

The average population density of the Poltava region – 50.7 inhabitants/km²:

$$D = \frac{P}{S} = \frac{1458213}{28748} = 50{,}7 \text{ inhabitants/km}^2.$$

The lowest population density is observed in Globinskiy district, this is due to large area of the district, even at relatively high number of population. A lot of the districts have an average regional density – predominantly the districts with agricultural specialization. The highest population density is observed in Poltava district, which is 53.5 inhabitants/km². This is due to the formation of agglomerative settlement systems at inter-district level around the administrative center. In addition, high population density is observed in cities – Komsomolsk, Kremenchug, Lubny, Myrhorod, Poltava (BULAVA, 2004; KRAVTSOVA, 2007).

More detailed description of how the population located in the region is calculated through an index of population concentration:

$$IKH = \frac{\sum |P_\text{ч} - S_\text{ч}|}{2};$$

Share of districts area:

$$S_\text{ч} = \frac{S_\text{р-н}}{S_\text{обл}} \times 100\%;$$

where: $S_\text{ч}$ – share of district area;
$S_\text{р-н}$ – area of the district;
$S_\text{обл}$ – area of the region

Share of districts population:

$$P_\text{ч} = \frac{P_\text{р-н}}{P_\text{обл}} \times 100\%;$$

where: $P_\text{ч}$ – share of district population;
$P_\text{р-н}$ – population of the district;
$P_\text{обл}$ – population of the region

An index of population concentration in Poltava region – 37.5%, indicating the uneven distribution of population in the region (table 1). A large proportion of the population is concentrated in the large cities such as Poltava, Komsomolsk, Kremenchug, Lubny, Myr-horod. Among the districts of the region the largest concentration of population is observed in Poltava and Kremenchug districts, the lowest – in Myrho-rodskiy, Hrebinkivskiy, Carlivskiy, Lubenskiy and Pyryatynskiy districts.

Table 1. Calculation of an index of population concentration in Poltava region
Tabela 1. Wartość współczynnika koncentracji ludności w obwodzie połtawskim

№	Districts	The population of the district (thousands people)	The area (km ^{2})	Xi (share of district area)	Yi (share of district population)	|Xi – Yi|
1.	Velykobahachanskiy	26,3	1019	3,545	1,786	1,761
2.	Hadiachkiy	56,2	1595	5,548	3,811	1,737
3.	Globinskiy	47,4	2474	8,606	3,214	5,391
4.	Hrebinkivskiy	23,4	595	2,07	1,587	0,483
5.	Dicanskiy	19,7	679	2,362	1,336	1,026
6.	Zenkivskiy	36,5	1361	4,734	2,475	2,259
7.	Carlivskiy	35,9	854	2,971	2,435	0,536
8.	Kobelyakskiy	44,9	1823	6,341	3,045	3,296
9.	Kozelshchinskiy	20,7	927	3,225	1,404	1,821
10.	Kotelevskiy	20,1	795	2,765	1,363	1,402
11.	Kremenchug	321,7	1244	4,327	21,816	17,489
12.	Lokhvitskiy	45,3	1303	4,532	3,072	1,462
13.	Lubnu	81,6	1420	4,939	5,534	0,594
14.	Mashevskiy	20,3	889	3,092	1,377	1,716
15.	Myrhorodskiy	73,9	1558	5,42	5,012	0,408
16.	Novosanzharskiy	35,9	1272	4,425	2,435	1,996
17.	Orzhytskiy	25,3	980	3,409	1,716	1,691
18.	Pyryatynskiy	33	863	3,002	2,238	0,763
19.	Poltava	358,2	1408	4,898	24,291	19,391
20.	Reshetylivskiy	27	1010	3,513	1,831	1,682
21.	Semenivskiy	27,2	1275	4,435	1,845	2,591
22.	Khorolskiy	36,4	1062	3,694	2,468	1,226
23.	Chornuhynskiy	12,4	682	2,372	0,841	1,531

24.	Chutivskiy	24	861	2,996	1,628	1,367
25.	Shishatskiy	21,3	799	2,779	1,44	1,335
Σ			1474,6	28748	100	100	74,954
Iк, %							37,477

Settlement system of Poltava region most affected by the factor of geographical position and functional structure of settlements. Poltava region is a part of the Northeast interregional settlement system, which is characterized by a high proportion of urban population share (BULAVA, 2004).

Identification of the main centers of population distribution will help to evaluate territorial characteristics and so-called "growth points" of the region (fig. 2).
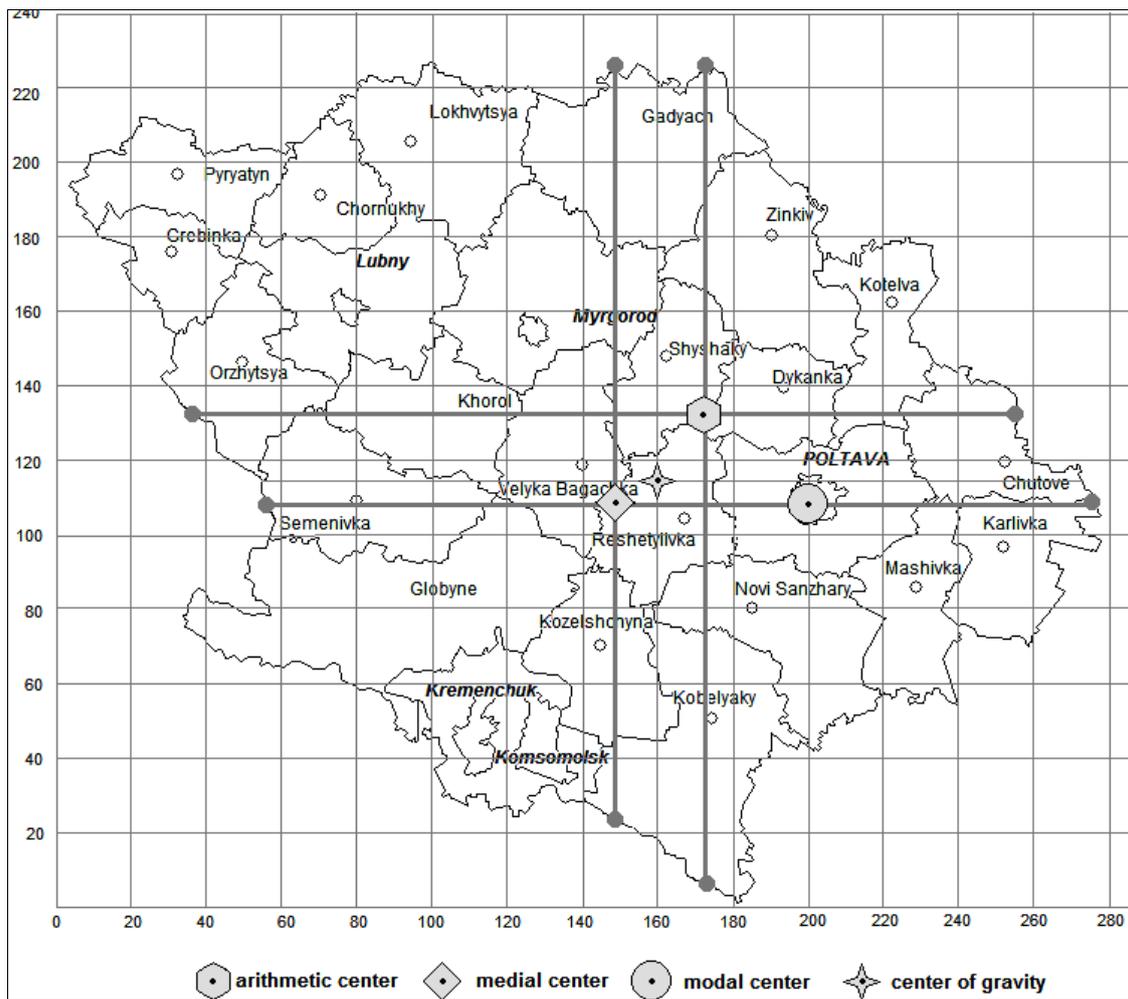

Fig. 2. Centers of spatial distribution of the population in Poltava region (calculated and constructed by the authors)
Rys. 2. Centra przestrzennego rozmieszczenia ludności w obwodzie połtawskim (obliczenia i konstrukcja własna)

Modal center of population distribution of the region is located at the point of highest concentration of population, in this case in the city of Poltava which is the regional center. Median center divides the region into four quarters and is located in the center with respect to the major cities with a large concentration of population (NIEMETS et al., 2014).

The arithmetic center of population distribution is calculated by the following formula:

$$x = \sum_{1}^{25} P_i \times L / P = 106$$

$$y = \sum_{1}^{25} P_i \times L / P = 147,2$$

where: P_i – population of the district (region); L – distance between the vertical (horizontal) straight; P – population of the region.

Arithmetic center of Poltava region is located in Reshetilovka near the center of the region. Nearby is Poltava district with high population density, affecting at the location of the object.

The dispersion of the population is determined by calculating the center of gravity:

$$x_0 = \frac{\sum_1^{25}(p_i - p_i') * x_i + p_i' x_i'}{\sum_1^{16} p_i} = 92,7$$

$$y_0 = \frac{\sum_1^{25}(p_i - p_i') * y_i + p_i' y_i'}{\sum_1^{16} p_i} = 139,1$$

where: x_0, y_0 – coordinates of the center; p – population of the region; p_i – population of the districts; p_0 – population of the regional centers; x_i, y_i – coordinates of the districts; x_1, y_1 – coordinates of the regional centers.

The center of gravity of population distribution in Poltava region is located between two major cities of the region – the city of Poltava and the city of Kremenchug.

To determine the skewness of the spatial distribution of the population of the region we used the nearest neighborhood analysis (KRAVTSOVA, 2007; SEGIDA, 2013):

$$R_n = \frac{\overline{D}}{0,5 * \sqrt{\frac{S}{N}}} = 2,1,$$

where: R_n – distance to the nearest neighbor; D – the average distance between the regional centers; S – area of the region; n – number of regional centers;

$$D = \frac{r_1 + r_2 + r_3 + \dots r_n}{n};$$

$r_1 + r_2 + r_3 + \dots r_n$ – distance between each point; n – number of neighborhood between districts.

After determining the average distance to the nearest neighbor in Poltava region, we can note that the arithmetic mean of the actual distance between each district center and its nearest neighbor rather small (37.7 km), the ratio is close to two and is 2.22 km – suggests strong links between districts. The cities are concentrated in the region compactly, with close proximity and high availability. Most of "neighbors" have Reshetylivskiy and Mirgorodskiy districts, as this districts of considerable length located in the center of the field.

CONCLUSIONS

Administrative division of Poltava region includes 25 districts, 15 cities [5 of them – cities of regional subordination (Komsomolsk, Kremenchug, Lubny, Myrhorod, Poltava) and 10 of them district-level towns)], 21 urban settlements and 1826 settlements of rural type. The region is characterized by low population density, which is 50.7 persons/ km², less than in Ukraine (73 inhabitants/ km²). The analysis shows the uneven distribution of population in the Poltava region. The centers of population distribution have also shown that people placed unevenly. Population tends to the cities of regional subordination, especially the city of Poltava and the city of Kremenchug. Calculating the spatial distribution of such indicators as median center, modal center and population center of gravity, it was found that people placed unevenly in the region, concentrated in large cities. In the settlement system of Poltava region are the following types: the first type includes the districts where population slowly decline (Poltava and Kremenchug) that have formed in the zone of the largest cities in the region; the second type includes the districts that are characterized by average rate of depopulation and settlement network (most districts of the region); the third type includes the districts with heavy reduction in population (Lokhvitskiy, Myrhorodskiy, Zenkivskiy, Hadiachkiy, Pyryatynskiy, Semenivskiy and Chornuhynskiy), the most intense decline in population and settlement network. In general, the process of settlement affected by many factors, including: socio-demographic, socio-economic, natural and historical, political, administrative, economic and organizational, technical and technological. Consideration of these factors of resettlement is necessary to identify the main problems and prospects of development of settlements. Analysis of the spatial distribution showed that the settlements, as opposed to population, are equally located in the region affected by this natural and historical factors. Between the administrative centers are observed close ties that affect their economic and social development.

REFERENCES

Bulava L. M., 2004: Geografiya svoeyi oblasti. Poltav-shchyna. Posibnyk. Oriyana, Poltava: 28 s. (in Ukrainian)

Kravtsova T. G., 2007: Transformaciya rozselennia nase-lennia Poltavs'koyi oblasti: tendencii ta perspektyvy rozvytku. RVPS Ukrayiny NAN Ukrayiny, Kyyiv: 203 s. (in Ukrainian)

Niemets L., Niemets K., Segida K., Pogrebskyi T., 2014: Regional settlement system as a factor of distribution of health care institutions (on example of Volyn region of Ukraine). Canadian Journal of Science, Education and Culture, 1(5) (January–June), vol. II. Toronto Press, Toronto: 185–191.

Oficiynyi sayt Golovnogo upravlyannia statystyky u Poltavs'kiy oblasti (Elektronnyi resurs). Rezhym dostupu: http://www.poltava stat.gov.ua/ (in Ukrainian)

Oficiynyi sayt Derzhavnoyi sluzhby statystyky Ukrayiny (Elekronnyi resurs). Rezhym dostupu: http://www. ukrstat.gov.ua (in Ukrainian)

Oficiynyi sayt Poltavs'koyi oblasnoyi derzhavnoyi administraciyi (Elekronnyi resurs). Rezhym dostupu: http://www.adm-pl.gov.ua/ (in Ukrainian)

Poltavs'ka oblast': pryroda, naselennia, gospodarstvo. Geografichnyi ta istoryko-ekonomichnyi narys. Vyd. 2-e pererob. i dop. Za red. K. O. Matsa. Poltavs'kyi literator, Poltava, 1998: 123 s. (in Ukrainian)

Segida E. Yu., 2013: Centrograficheskoe issledovanie rasseleniya naseleniya (na primere Khar'kovskoy oblasti Ukrainy). Mogilevskiy chasopis, 13, 1–2 (20–21). Mogilevskaya oblastnaya drukarnia shimeny Spiredoga Sobolya, Mogilev: 37–40. (in Russian)