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GIS mapping in the geodemographic studies (Case study of the Republic of Belarus)

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Abstract

The work deals with the options of using geoinformational technologies in the population geography as exemplified by the GIS-models of the rural population of the Republic of Belarus (RB). The methods to create GIS-model with a brief characteristic of the stages are presented. The comparative analysis of two methods of mapping of the relative demographic values (colour scales and map-image transformation) is conducted. Technical and practical aspects of the map-image transformation method in geodemography are considered in the first part of the article.

Trends of dynamics of rural population size for the period of 1959–2009 years are detected and characterized in the second part of the article. Spatial patterns were identified in accordance with these trends of the rural population of the RB. The area of RB is typified on the basis of the character of demographic dynamics and natural movement processes of rural population. There have been identified three types of districts by the nature of the dynamics of rural population for the period of 1970–2009 years: stable, growing and shrinking; and three types of natural population movement dynamics for the same period in accordance with spatial and temporal heterogeneity of rural depopulation.

Keywords: population geography, GIS-modelling, demographic dynamics, rural population of the RB, spatio-temporal shifts.

Introduction

The recent trends in the development of geodemographic studies show the significant growth in their number and the use of increasingly sophisticated tools. The considerable amount of demographic statistical information calls for their systematization using the mathematical methods and the application of computer software.

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The characteristic feature of the modern cartographic tools is the wide use of the computer and GIS technologies. For processing spatial data, the Environmental Systems Research Institute (ESRI) has created the ArcGIS package, which allows visualising data, performing mathematical calculations, spatial and geostatistical analysis in 2- and 3-dimensions. This software package has been customized in the economic and geographical studies on the population of RB in the Scientific Research Laboratory of Regional Demographic Problems on the Faculty of Geography of BSU since 2002 with the participation of the authors.

The first GIS developed was the Demographic Atlas of Belarus (2002), followed by the Rural Areas of Belarus GIS featuring the rural population places in 1959–1999 and the GIS-Gallery of the demographic potential of the rural areas of the country using the grid-model and the method of pseudo-isolines (2003). In 2004 the Rural Population of Belarus GIS was created, showing the dynamics and the spatial patterns of the development of demographic processes in 1989–1999, which was updated with the results of the 2009 census of the RB (Antipova, E. 2008).

Methods and information basis of the "Rural Population of Belarus" GIS

The current demographic record materials from the National Statistical Committee of the Republic of Belarus, the 1989 (USSR), 1999 and 2009 (RB) population censuses formed the information basis of the research. The works of the Russian scientists in the field of geoinformatics and geoinformational thematic mapping served as the theoretical and methodological background of the research (Tikunov, V.S. and Tsapuk, D.A. 1999; Kapralov, E.G., Koshkarev, A.V. and Tikunov, V.S. 2004).

The research resulted in the development of the new methodological approach to the geographic systematization through the solution of the following theoretical and practical tasks:

1. Creation of the electronic database of the rural areas of Belarus in the regional level – according to the administrative divisions since 1989;
2. Creation of the demographic GIS "Rural population of Belarus" of the regional level (based on the data of the 1989, 1999 and 2009 population censuses);
3. Elaboration of the dynamic comparative geographic GIS-model of the rural population of Belarus on the basis of the GIS-technologies and the ArcGIS software package.

The structure of the general DemoGIS "Rural population of Belarus" comprises several projects that are grouped into thematic blocks with a system of special indices (*Table 1).*

Table 1. Structure of the "Rural population of Belarus" DemoGIS

GIS project name	GIS level	DemoGIS thematic groups	Demographic indices of the thematic groups	Number of themes in the project	Demographic datatimelines	Data dependence structure	Map themes in the project
GIS project 1'Rural population of Belarus'	regional	1. Natural population movement	birth rate, mortality rate, natural population increase/decrease	64	retrospective (1989, 1999), present (2004)	plex	Analytical maps of the demographic indices
		2. Population structure by sex and age	population size and the share of the main age groups		retrospective (1989, 1999), present (2004)	plex	
		3. Migration	number of immigrants, number of emigrants		retrospective (1999)	plex	
		4. Population settlement	population size of the rural settlements		retrospective (1959, 1979, 1989, 1999), present (2004)	hierarchical	
GIS project 2 'Rural population of Belarus'	local	Demographic potential	rural settlements population size	354	retrospective (1959, 1979, 1999), present (1999), perspective	relational, hierarchical	Analytical maps of the demographic potential
GIS project 3 'Complex demographic zoning of the rural area of Belarus'	regional	1.Demographic situation	Demographic types identifying: dynamics of the population increase/decrease, dynamics of the birth- and mortality rate, degree and speed of depopulation, demographic load, population ageing, agricultural load, settlement distribution	4	retrospective (1989, 1999), present (2004)	hierarchical	Integral maps of the demographic conditions
		2. Settlement system					

The study indicated that the work on the creation of a demographic GIS using the ArcGIS 9.3, regardless of the GIS level chosen, has a consistent methodology and can be theoretically performed in three steps (Antipova, E. 2007a).

The first step consists of the analysis of the demographic data that is processed to choose the raster map basis and to create the necessary layers of the spatial data. As the second step, attribute table of the vector polygonal theme are created. The third step involves mapping on the basis of the values of a certain field in the attribute table. A major part of the derived demographic indices was calculated using the tools for the attribute information processing in the GIS.

The most widespread method of illustrating the area population rate is creating population density maps (*Figure 1*) using the method of isolines in conjunction with the method of colour scales (isolines with layer colouring). It consists of the interpolation of the population density values on the surface, each point of which is defined by the pair of the x and y coordinates.

The method of the scaled map symbols (dot method) is best suited for the mapping of the average rural settlement size.

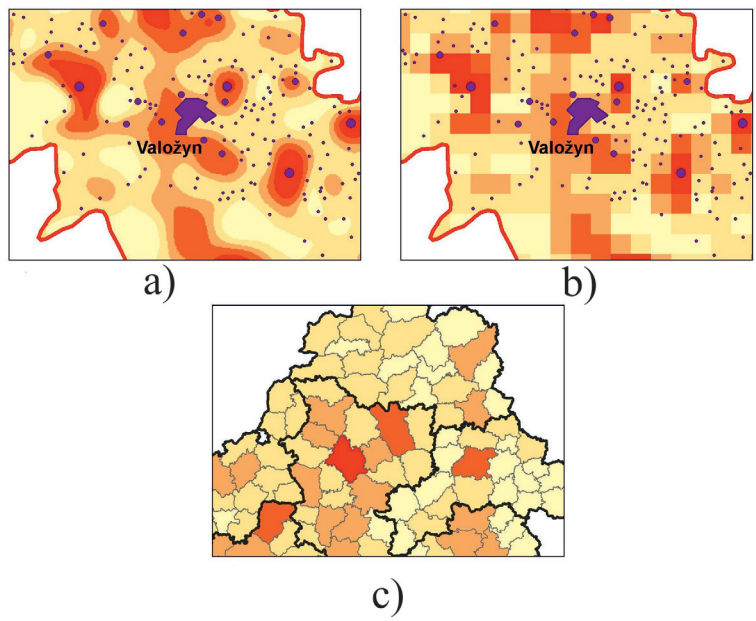

Fig. 1. Methods of the population density mapping. – a = method of isolines with a layer colouring; b = method of grid networks; c = cartogram method. (Hereinafter inscriptions are developed according to Resolution of the State Committee of Land Resources, Geodesy and Cartography of the Republic of Belarus, 23.11.2000, No. 15 "Transliteration Instruction of the Republic of Belarus geographical names by Latin alphabet")

It implies building a population density marker in a semi-centre point of each region, the sizes of the markers depending on the selected classification key.

The best suited methods of mapping the relative demographic values are the methods of the diagrammatic maps and colour scales (cartograms), which give an illustrative view of the cartographic image transformation method, that involves scaling dispersion of the total data for every region, as well as the anamorphosis method or the area of the administrative-territorial unit according to the value of the index (Gusein-Zade, S. 2008). For instance, the map "Structure of the rural settlements in Belarus according to the population classes" was created with the use of the method of localised pie-charts *(Figure 2*).

The colour scales method is widely used in geodemographic studies and it was developed in the previous works of the authors (Myshlyakov, S. and Fakeyeva, L. 2005).

For mapping the characteristic with substantial regional differences, the transformed image – anamorphosis – is the most informative form of visualising the spatial differentiation of the index *(Figure 3).*

Let's have a closer look at the map-image transformation method. The creation of such transformed maps (*density-equalized maps* or *cartograms*) is methodically based on the work of American researchers Gastner and Newman "Diffusion-Based Method for Producing Density-Equalizing Maps" (Gastner, M. and Newman, M. 2004).

The use of the method that is physical by its nature that was proposed by these scientists was organised in the ArcGIS 9.3 software package with the help of the tool for the cartogram creation (created by T. Gross, ESRI) that is distributed for free (www.esri.com/arcscripts). The source data should be the polygons (object class and layers can be used too) with the necessary attribute parameters for the calculations.

The data is output exclusively to the created object class (in the existing personal database). The additional key parameters are the density smoothing factor and the number of cells in the analytical grid. The first parameter, having the default value of 1, can have values from 0 to 100. The second parameter is the number of cells in the analytical grid and it varies from 128 to 4,096 with the default value of 512.

The lower is the cell size, and the bigger is the number of cells, respectively, the more precise is the cartogram in showing the differentiation of the phenomenon.

Therefore, the use of the new methods of dynamic mapping in the population geography allows to use the special advantages of the GIS technology (functionality, scalability, use of visual aids, easy way of updating, efficiency, compatibility, modelling) and develop the interactive reference informational GIS projects for practising the regional management.

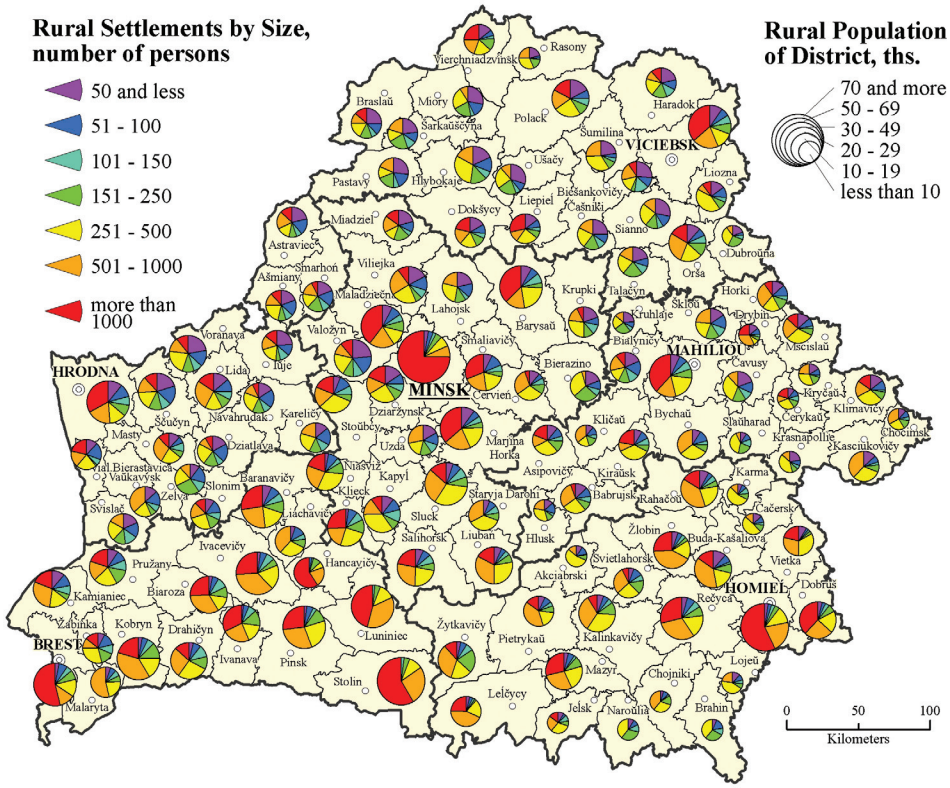

Fig. 2. Structure of the rural settlements in Belarus by the population classes, 2009

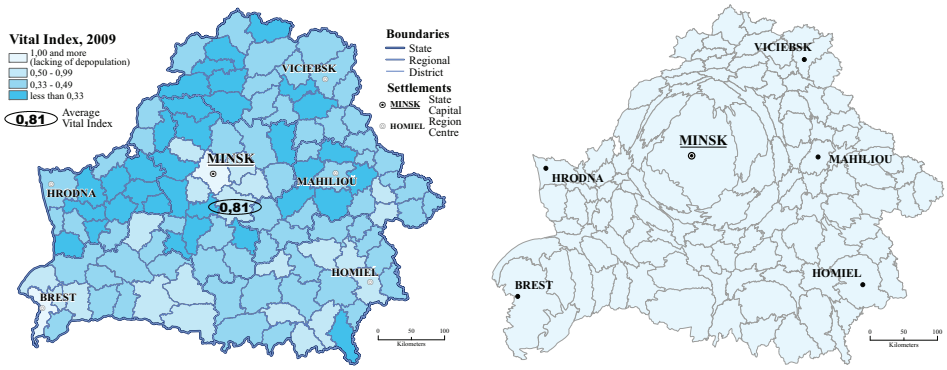

Fig. 3. Comparative characteristics of the cartographic images shown with the use of the method of colour scales (left) and transformations (right)

Trends of rural population size dynamics in Belarus

Natural increase or decrease, migratory movement, losses caused by warfare and by other political cataclysms (deportation, repression), the harmful effects of the Chernobyl disaster, population loss caused by the waves of emigration determined population dynamics in Belarus over the 20th century.

The distinctive features of the periods between censuses and the main types of population trends have been identified. It was based on the analysis of factors controlling rural population dynamics: the rate of increase or decrease in population size and of the ratio of the rural segment within the total population of Belarus (Antipova, E. 2008).

The period between 1959 and 1970 was characterized by the dominance of economic factors and it proceeded up to 1986. Urbanization played the role of the key factor at that time. It was the first period of the negative rural population dynamics on macro geographical level. Micro geographical level of research indicated the first wave of rural demographic disaggregation and the territorial differentiation of demographic dynamics. Thus, some districts with a positive dynamics of population size were elicited against the general background of rural population decline (0.1 percent per year for Belarus) as a result of migratory outflow. 69.2 percent was rural within the overall population of Belarus in 1959. Thus, the rural population prevailed in the demographic space during this period.

The period of 1970–1979 years was characterized by an accelerated rate of rural population decline (1.5 percent per year), the second wave of rural demographic disaggregation, the demographic space frame of settlement violation and the overall restructuring. The urban transition was completed on macro geographical level in the first place and a natural decrease of the rural population started.

The period between 1979 and 1989 is distinguished by the influence of ecological factor. Rural population experienced further decline and spatial redistribution of demographic potential during this period. Ecological decline under the influence of the Chernobyl accident and the socio-economic development of the country did not change trends in the dynamics of rural population essentially at this stage. Negative dynamics had not strengthened.

The transformation between 1989 and 1999 changed the demographic course in the country due to the impact of several factors. There had been political and socio-economic changes during these years: the disintegration of the Soviet Union, the switch of the former member republics of the USSR to the independent development, restructuring and the economical and social reforms. The emerging socio-economic crisis had deteriorated the living conditions of people. This caused a breach in the dynamics and spatial distribution of the population, the nature of demographic reproduction.

The process of urbanization slowed down markedly. The scale of internal rural to urban migration has been reduced thoroughly. Changes in population reproduction started following the disturbances in the migration process. Radio phobia and insecurity, unemployment, indigence caused a sharp decline of fertility. Deterioration of living conditions and health contributed to the increase of mortality.

In the end, natural increase had turned into natural population decline that affected not only elderly rural population, but also the relatively young urban cohorts (Manak, B. 1992; Manak, B. and Antipova, E. 1998).

The major trends in rural population size dynamics of the period 1989–1999 were:

1. Rural areas of Belarus were characterized by a persistent negative dynamics (1.2 percent per year), but the peak of the greatest annual rate of decrease (2.0 percent per year) was already passed in the late 1980's.

2. On micro geographical level only few districts retained positive or stable dynamics of the rural population as acceptor areas of demographic capacities. These districts usually were located in the gravity zone of cities (Brest, Homiel, Minsk) but none of them were found in Hrodna and Mahiliou regions.

3. The type of districts with negative demographic dynamics had become dominant in the rural regions (113 out of 118 districts) with the threshold rate of annual population decline from 0.01 percent in Stolbtsy district, Minsk region up to 4 percent in Narovlya district, Homiel region.

This period is characterized by a second evolutionary trend of Belarus rural population dynamics: there was a structural castling on the macro level between the ratio of urban and rural populations. In 1959 the rural population made up 70 percent and the share of urbanites accounted for 30 percent, and the ratio became diametrically opposed by 1999. Urban transition was completed in Minsk region later than in all other regions of meso geographical level (Antipova, E. 2008).

The above mentioned trends strengthened the structural imbalances and increased spatial polarization in the distribution of demographic potential of the rural population. There was a third wave of demographic disaggregation of rural areas that changed the usual pattern.

Thus, RB started the 21st century with negative population dynamics. The total population decline was 0.05 percent, the rural one was 0.2 percent for the period of 1999–2009.

Major trends in rural population dynamics at the end of the twentieth century remained typical at the beginning of the twenty-first century:

a) Negative dynamics develops under the influence of various factors, major among them are: ageing, changes in reproductive attitudes of the population, migration outflow of the young working population from the rural areas;

b) The annual decline of the rural population tends to increase compared to 1999: in Brest region – 1.3 percent, in Viciebsk – 2.4 percent, in Homiel – 1.9 percent, in Hrodna – 2.2 percent, in Minsk – 1.9 percent, in Mahiliou region – 2.5 percent as a result of combined impact of the above mentioned factors.

The study of the demographic development of Belarus since the first population census in the year 1897 until present allowed to conclude that the general dynamics of the demographic processes is the function of social and demographic evolution, while the spatial differentiation is influenced by a complex of features in the development of agroeconomics, settlements, transport, communications and ecology, as testified by the findings of the correlation and regression and factor analyses (Fakeyeva, L. 2008a).

Socio-demographic factor has the evolutionary dependency and has been determinant in the genesis of the depopulation process of the rural areas in Belarus that could already be observed back to the year 1975.

Over the 1970–1979 period, the territorial disparities were caused (similar to the first half of the 20th century) by the *agroeconomic* factor, that was studied with the involvement of indices such as the gross revenue in agriculture, land quality, and the power available in farming. Between 1989 and 2008 the *settlement* factor (the population change of rural settlements, the degree of urbanization) and the *transport and communication* factor (e.g. the density of paved roads) had been the dominant (*Figure 4*). The *ecological* factor have not had a substantial impact on the dynamics of the natural population movement in Belarus since the year 1986 in general.

In accordance with the trend of the rural population dynamics of Belarus characterized by the gradual downsizing for the period of 1970–2009 years, the following spatial regularities were identified:

– persistent long-term negative rural population dynamics is distinctive for peripheral districts with low agricultural potential or with extensive natural systems;

– the reduction of the rural population had set in later in areas of transition type with high agricultural or recreation potential, as well as in the zone of the "special Chernobyl region";

– large (support) cities are attracting rural migrants during the whole period studied;

– the capital region is an active and potential area of demographic growth due to immigration as well as to the natural factors of fertility which is more important for improving the demographic situation in the country.

The change of this share of districts within the total rural population is calculated to study the spatial dynamics. The vector of the spatial shifts of demographic potential for the period 1970–2009 was identified with the qualitative characteristics of the dynamics (growth, stability, or decline). As a result, three types of districts have been identified by the nature of the dynamics of rural population: growing, stable, and shrinking (*Table 2*).

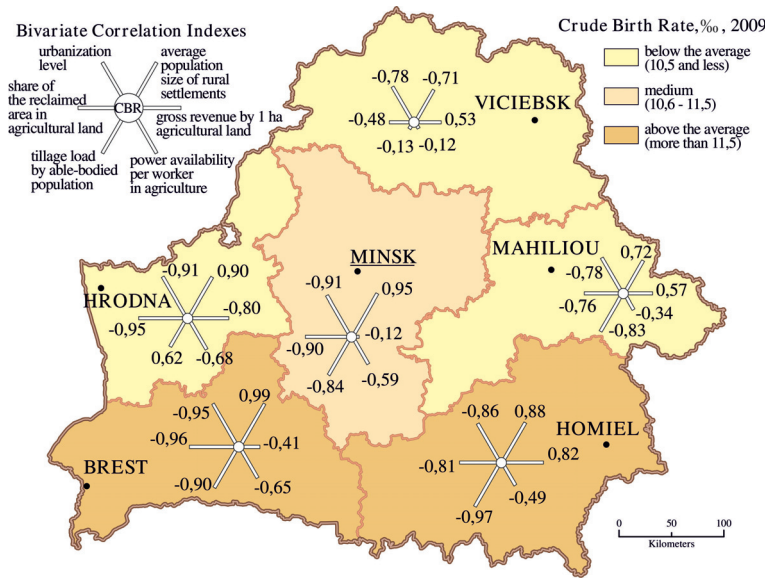

Fig. 4. Meso regional distribution of the factors of the geodemographic dynamics in the rural areas of Belarus

Table 2. Characteristics of districts types of Belarus by the nature of the dynamics of rural population

Type	Number of districts	Share within the total population, %		Share within the territory, %	Urbanization rate, %	
		1970	2009		1970	2009
Type 1	22	18.85	36.59	19.97	47.12	84.01
Type 2	60	49.62	42.44	48.72	47.95	62.2
Type 3	36	31.53	20.97	31.31	33.22	61.25

Source: Own compilation based on Population of Belarus: statistical digests 1970–2009.

Type 1. Growing. Southern agricultural districts of Polessye have an increasing share within the country's population. This region has a traditionally favourable demographic situation (Stolin, Gantsevichy, Luninets). These are districts with typically high agricultural potential, characterized by an increasing share within the population of the republic over the whole study period. Another large group of the growing districts does not have a compact area of distribution. This subtype is a mosaic of scattered districts located in the suburban zone of major cities and transport corridors. The share of this

subtype is steadily increasing. Mahiliou region is the only exception where the periods of growth have alternated with those of loss.

Type 2. Stable. This type is represented by agrarian districts with centres in medium and small urban settlements. Districts with conditional stability have not changed its share of the total rural population significantly. Geographical areas of this type relate to the zones of the average level of intensity dynamics of the basic demographic processes.

Type 3. Shrinking. This type is represented by peripheral districts of the country that are located in administrative regions of environmental and recreational profile, and the regions affected by man-made disaster. Homiel and Mahiliou regions have suffered the most sharp decrease in population over the study period. This territory was affected by the Chernobyl accident which had halved the share of this type within the total population.

These districts reduced the share of its population over the study period. The process has got the reverse vector at the present stage only, but the intensity and duration is still very low to cover the massive and prolonged thirty-year losses.

The peripheral districts of Mahiliou region and districts along the line of Mahiliou–Babruisk experienced the second largest decline in the share within the total population over the study period. Peripheral districts located north-west of Minsk region, west of Viciebsk and east of Hrodna belong to the shrinking type of dynamics, too.

The absolute decrease values are minor among the districts of this type. Thus, centre of gravity of the rural population has shifted in two directions: zonal – from north-east to south-west and azonal – to the suburbs of large cities. The second vector becomes increasingly significant with each passing year and the share of the population of suburban areas is growing faster and more intensive than that of the homogeneous agricultural areas.

Spatiotemporal patterns of demographic development of rural areas in Republic of Belarus

The mapping of the main demographic processes in the rural areas of Belarus in terms of their dynamics indices during the years 1989–2009 highlighted a substantial differentiation, resulting from the multi-directional evolutionary and transformational influence of socio-economic and spatial factors.

Rural population of Belarus has been reducing due to natural population decline mainly, which has exceeded migration outflow from the villages since 1992. Regressive demographic trends in Belarus appeared at the outset of the first "demographic transition" in rural areas by the mid-1960s.

These regressive demographic trends have taken place all over the republic, but the process of their expansion and development has been uneven in time and space. The differences in duration and indices of the increase in mortality and of decline in fertility are manifested on the meso level (i.e. of regions) and intensify on the micro level (of districts).

Natural rural population decline had grown to 3.8‰ both by reducing the birth rate to 12.3‰, and increasing mortality up to 16.1‰ by the end of 1980. Natural decrease had reached 13.8‰ in ten years by 1999. In 2009, births exceeded deaths by 13.0‰.

The natural decrease in rural population of Belarus began in the late 1970's as a whole. It was recorded in 1975 in Viciebsk, Hrodna and Mahiliou regions, in Minsk – in 1980, in Brest and Homiel regions – in 1985. Meso level differences in the completion of the first "demographic transition" are clearly seen from north-east to south-west i.e. from the agro-extensive areas to agro-intensive ones (Pirozhnik, I. 1986). Minsk region is an exception. It is the region with the highest social-economic potential, concentrating various functions of a large urban centre and demonstrating a relatively more stable demographic development (Fakeyeva, L. 2008b).

The direction of the population distribution axis is explained by the territorial differentiation of population losses in the Great Patriotic War. In the pre-war period the population on the territory of Belarus was located fairly evenly and significant meso level differences were not observed. Demographic potential shifted to the Minsk and Brest regions during the second half of the twentieth century (Antipova, E. 2007b).

The differentiation in development of demographic processes is greatly enhanced on the micro level. Spatial spread of the process of rural depopulation in the direction from north-east to south-west from the agro-extensive districts to agro-intensive districts is closely related to the settlement pattern which changes in the same direction from the prevalence of small-sized to that of large-sized settlements.

The first "demographic transition" has been completed in all rural areas of Belarus by the end of 1980. Five Polessye districts and typical suburban Minsk, Homiel and Brest had small natural growth only. The stimulating role of cities in the Homiel and Brest regions enhanced zonal features, which are expressed in a high fertility and low mortality in the southern part of Belarus.

Currently, all Belarus districts, except for those of Minsk and Brest, are characterized by a natural decrease of rural population. 3 types of dynamics of natural population movement were identified in accordance with spatial and temporal heterogeneity of the rural depopulation (*Table 3*).

Type 1. Developing. It includes suburban and urban, agrarian Polessye districts with a relatively favourable demographic dynamics (for the period of 1970–2009 CBR from 16.5 to 12.6‰, CDR from 8.5 to 19.4‰).

Table 3. Characteristics of district types by the dynamics of natural movement of rural population

Type	Number of districts	Territory, 1,000 km²	Share within total area, %	Population, 1,000 people		Share within total population, %	
				1970,	2009	1970	2009
Type 1	11	18.00	8.66	670.4	476.5	13.3	19.7
Subtype 1.1	8	12.67	6.09	422.2	232.4	8.4	9.6
Subtype 1.2	3	5.33	2.56	248.2	244.1	4.9	10.1
Type 2	60	109.67	52.76	2,615.5	1,238.8	52.1	51.3
Subtype 2.1	33	58.32	28.06	1,439.9	743.3	28.7	30.8
Subtype 2.2	22	42.20	20.30	836.9	301.3	16.7	12.4
Subtype 2.3	5	9.16	4.41	338.7	194.2	6.7	8.1
Type 3	47	80.20	38.58	1,737.7	698.1	34.6	29
Subtype 3.1	39	67.47	32.46	1,370.9	544.9	27.3	22.6
Subtype 3.2	8	12.72	6.12	366.8	153.2	7.3	6.4

Table 3. – continued

Type	CBR, ‰		Fertility dynamics index 2009/1970	CDR, ‰		Mortality dynamics index 2009/1970	CDI	
	1970	2009		1970	2009		1970	2009
Type 1	16.5	12.6	0.77	8.5	19.4	2.28	0.52	1.54
Subtype 1.1	16.4	11.8	0.72	8.4	21.3	2.53	0.51	1.80
Subtype 1.2	16.7	14.6	0.88	8.8	14.5	1.64	0.53	0.99
Type 2	15.8	10.9	0.69	9.6	24.7	2.57	0.61	2.26
Subtype 2.1	17.6	10.2	0.58	10.1	24.2	2.39	0.58	2.37
Subtype 2.2	13.9	12.1	0.87	8.8	26.1	2.95	0.64	2.15
Subtype 2.3	12.6	10.5	0.83	9.5	22.0	2.32	0.75	2.10
Type 3	12.5	9.3	0.74	10.4	28.2	2.72	0.83	3.03
Subtype 3.1	12.3	9.7	0.79	10.4	27.9	2.67	0.85	2.87
Subtype 3.2	13.6	7.3	0.54	9.9	29.8	3.01	0.73	4.07

Source: Own compilation based on Population of Belarus: statistical digests 1970–2009.

Type 2. Stable. It comprises transitional districts, the demographic development is close to the average (CBR from 15.8 to 10.9‰, CDR from 9.6 to 24.7‰).

Type 3. Depressive. It combines adverse peripheral districts (CBR from 12.5 to 9.3 ‰, CDR from 10.4 to 28.2‰), with low demographic and agricultural potential located in Poozerye, on the Neman lowland and Lida plain, with districts of high agricultural or tourist recreational potential in accordance with *Figure 2* (Fakeyeva, L. 2009).

Type 1. Developing type includes 11 districts, characterized by stable high fertility and low mortality, positive dynamics of natural movement. Currently, only these areas of Belarus are capable of self-development and demographic reproduction. Developing type includes two subtypes: southern and dispersed.

Subtype 1.1. Developing southern subtype comprises 8 Polessye agrarian districts that traditionally have an advantageous demographic situation. The combination of the confessional and ethnic structure, economic activities and settlement pattern in these extensive agrarian regions forms a stable area with the lowest level of rural depopulation in Belarus.

Subtype 1.2. Developing dispersed subtype includes three suburban, industrial districts Minsk, Homiel and Brest, where 10 percent of rural population live and the share of these areas within the rural population is on a constant increase.

Type 2. Stable type unites 60 districts, where 51 percent of the rural population of Belarus is concentrated residing in 53 percent of the area. The stability of these districts with regard to the average Belarus indicators determines the stagnation of the demographic development. Currently, most stable areas are not able to the natural population increase without migration inflow, except for the areas of suburban subtype:

Subtype 2.1. Stable central-western region embraces 33 districts of the Belarusian ridge and large-sized settlement districts of lowland areas of Pripyat river, the majority of which belongs to industrial and industrial-agrarian sections, 8 – to agro-extensive section and 7 – to agro-intensive section (Pirozhnik, I. 1986).

Subtype 2.2. Stable south-eastern region consists of 22 large- and middle-sized settlement districts of the Polessye within Homiel region, where ca 12,5 percent of the rural demographic potential is concentrated. In this subtype there are mainly agro-extensive districts, five of them relate to industrial and agricultural, Mozyr, Babruisk and Svetlogorsk belong to industrial ones.

Subtype 2.3. Stable suburban areas include 5 urban industrial districts, with more than 8 percent of resident rural population in the country and with a constantly increasing proportion of the demographic potential in these areas.

Type 3. Depressive type unites 47 districts, representing 39 percent of the territory, and concentrates about 28,9 percent of the rural demographic potential.

These districts could be characterized by low fertility and high mortality during the whole research period. In 1970 already Conditional Depopulation Index (CDI) was less than one in the regions of this type, indicating narrowed type of the population reproduction. Depopulation Index had risen up to 3.03 in 2009.

Subtype 3.1. Depressive north-eastern subtype unites 39 districts, which are home to 22,6 percent of the population and the proportion of the demographic potential is declining. Most of them are represented by northern part of Belarus – Poozerie, with a low demographic and agricultural potential. Districts of this subtype had reduced demographic potential throughout the study period. This process cannot be stopped in a natural way due to the abruptly disturbed age structure.

Subtype 3.2. Depressive western subtype includes 8 districts, which concentrate around 6.4 percent of the demographic potential, occupy 6 percent of rural areas in RB, and are located on the Neman lowland and Lida plain. They are districts with high agricultural, tourist and recreational potential, and are characterized by a delayed onset of depopulation, but fertility decline has occurred rapidly and more intensely, coupled with the average national growth rate of mortality.

The complex typology according to the type of demographic reproduction processes in rural areas of Belarus that was developed in this study was based on the preliminary, private typologies implemented on the base of the consistent spatial patterns of the main demographic processes. The latter were found by the type of the natural movement dynamics; features of the age structure; intensity of the decrease of the population number with provision for the effect of the economic and geographic factors that were identified using the multidimensional methods of mathematical analysis. The typologies thus developed provided the evidence of the geodemographic spatial polarisation of the central-peripheral quality.

As a result, 3 region types have been demarcated with clear geographical borders.

1. Comparatively stable type has the most favourable demographic characteristics and a potential for demographic self-development. The type comprises two subtypes:

1.1. Subtype of homogeneous comparatively stable regions with lower-than-the-average natural loss of population, the shortest duration of depopulation, the smallest disproportion in the age structure, the average or high rate of working population, a growing or stable overall rate of the rural population, and decreasing intensity of migration outflow.

1.2. Subtype of comparatively stable nodal regions with variably decreasing natural population, and regressive age structure; average, high or rising rate of working population, increasing population size, migration inflow or migration outflow with a trend of decreasing intensity.

2. Unstable type consists of the regions with average natural depopulation, average duration of depopulation, regressive age structure, low or average rate of the working population, changing rate within the total population size, and with migration outflow of an increasing intensity. Demographic development of these regions practically coincides with the trends that are characteristic to the rural population in Belarus in general (*Table 4, Figure 5*).

Table 4. Parameters of the region types in Belarus according to the type of demographic reproduction processes of rural population

Type	Number of districts	Share within total population, %		Share within total area, %	Natural population increase (+)/ decrease (-)		Migratory increase (+)/ decease (-)	
		1970	2008		1970–1979	1999–2008	1970–1979	1999–2008
Type 1	22	17.4	16.9	17.3	+	-	-	+
Subtype 1.1	7	5.2	4.1	5.2	+	-	-	-
Subtype 1.2	15	12.2	12.8	12.1	+	-	-	+
Type 2	46	38.0	36.6	39.8	+	-	-	-
Type 3	50	44.6	46.5	42.9	-	-	-	-

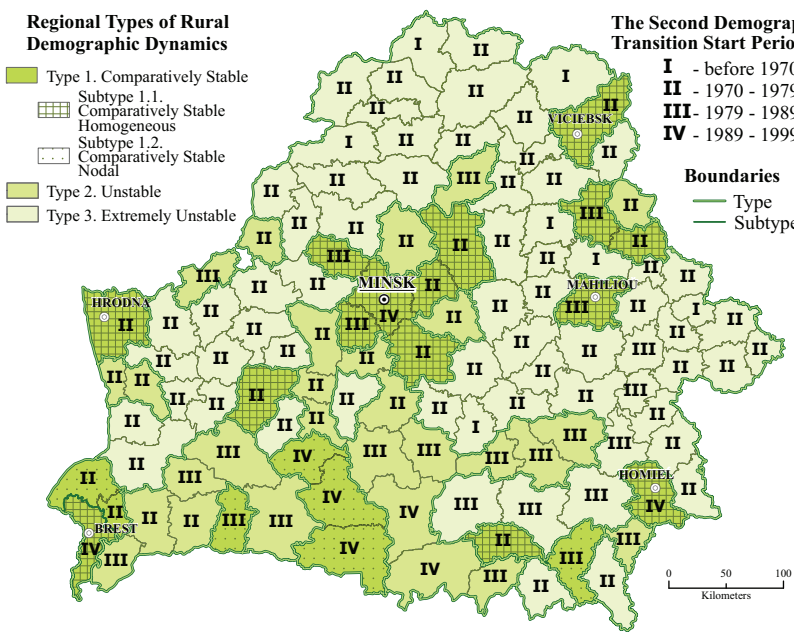

Fig. 5. Typology of the regions of Belarus according to the character of demographic reproduction processes within the rural areas, 1970–2009

3. *Extremely unstable type* includes areas with the natural decrease above the average, the longest duration of the depopulation process, sharply broken age structure, the low rate of able-bodied population, decreasing or stagnating population rate, migratory outflow. This type is the demographic periphery of rural Belarus.

Conclusions

Consequently, the research conducted shows that the geoinformational approach can be used not only to create the maps that follow the requirements of the socio-economical cartography, but also to construct GIS models that have massive opportunities for performing analytical operations. The "Rural population of Belarus" GIS developed can be used in government administration on the state, regional and local levels as a geographic and demographic interactive reference informational resource.

The spatial and temporal analysis of the rural population dynamics conducted for the period of 1970–2009 years allowed to formulate main conclusions:

– The dynamics of rural population of Belarus has an evolutionary character. The increasing reduction in the population size is the essential contemporary trend that leads to the decreasing role of the rural population in the formation of geodemographic space.

– Macro geographic trends illustrate the end of «urban transition», which is characterized by structural shift in rural areas from the dominant rural type of districts to suburban, and the "castling" of the urban and rural populations in the formation of geodemographic space.

– Spatial and temporal combination of factors shows the cyclic character of population dynamics on the one hand, and the centre-periphery polarization properties on micro geographic level on the other hand.

– Economic-geographical characteristics of the rural Belarus population dynamics testify to the geographically differentiated roles of districts in the formation of demographic space in Belarus, which is determined by a strong presence of suburban and suburban-ring districts, and by a weak presence of the peripheral districts.

The main spatial and temporal trends in the natural movement of rural population in the period of 1970–2009 are:

– an area of demographic depression is trending in the direction from north-east to south-west; south Polessye districts are characterized by the highest stability of the zonal demographic parameters;

– the demographic space has been fragmented under the influence of the development of urban settlement network and of the improvement of demographic parameters in suburban districts.

The spatiotemporal analysis of the main demographic parameters has shown that the rural areas of Belarus vary across the country significantly. These differences are intensified under the influence of the large urban settlements, and the region types identified have different potential of reaching the demographic optimum. This situation calls for an increasingly differentiated demographic policy to ensure the national demographic security.

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