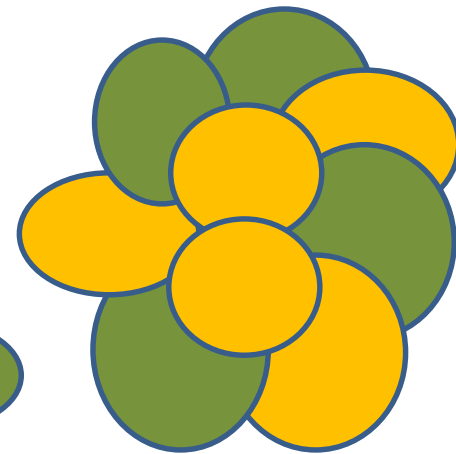
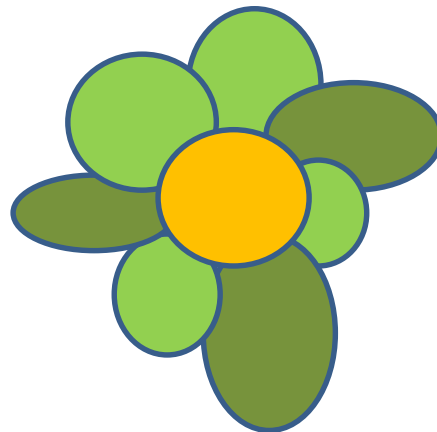
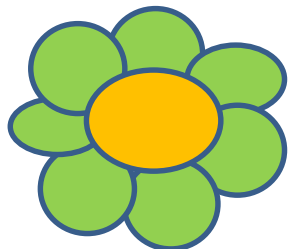




Map of Dynamics of Changes in Cities and Neighbouring Communes

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Is the city growing?

Size in terms of territory, or in terms of demography does not reflect the development of the city to consider other factors in the development of socio-economic identified as significant in the annual reports prepared by Mercer Human Resource Consulting. The reports include an examination of the quality of life in cities, based on the 39 factors compiled in 10 categories:

- *Political and social environment,*
- *Economic environment ,*
- *Socio-cultural environment,*
- *Medical and health considerations,*
- *Schools and education,*
- *Public services and transportation,*
- *Recreation ,*
- *Consumer goods,*
- ***Housing,***
- *Natural environment.*

The research assumes that the analysis of the dynamics of changes in the residential space per person provides the best indicator of changes occurring in the urbanised area.

In practice, a given area might become **depopulated**, and an **increase** in residential space per person will be observed.

It is important to find a **rate** that will allow us to describe the changes in the relationship between these phenomena (urbanised area and population)

Methods for analysing the dynamics

In the first step of examining the dynamics, we calculate a sequence of chain indices, where the assumed basis in a time series is an expression preceding the examined expression.

$$X_{1/0} = \frac{X_1}{X_0}; X_{2/1} = \frac{X_2}{X_1}; \dots \dots; X_{n/n-1} = \frac{X_n}{X_{n-1}}$$

At a subsequent stage, the dynamics (index change) of examined variables within the time bracket was determined, assuming the initial year of observation as the basis of the time unit (a series of one-base indices). It was assumed that in the initial year of the analyses, i.e. 2002, the examined phenomena (population, residential floor space per person and the total residential floor space) had the value of one, and the values of the indicator in subsequent years were the product of the abstract number in a given year and the change index.

Table 1. Algorithm for describing change dynamics

	Year 1	Year 2	Year 3	Year 11
Observed value	X_1	X_2	X_3		X_{11}
Sequence of chain indices	-	$X_{2/1} = \frac{X_2}{X_1}$	$X_{3/2} = \frac{X_3}{X_2}$	$X_{11/10} = \frac{X_{11}}{X_{10}}$
Change dynamics since the initial time of observation	1	$1 * X_{2/1}$	$1 * X_{2/1} * X_{3/2}$	$1 * X_{2/1} * X_{3/2} * \dots * X_{11/10}$

Chart 1. Dynamics of population in selected cities

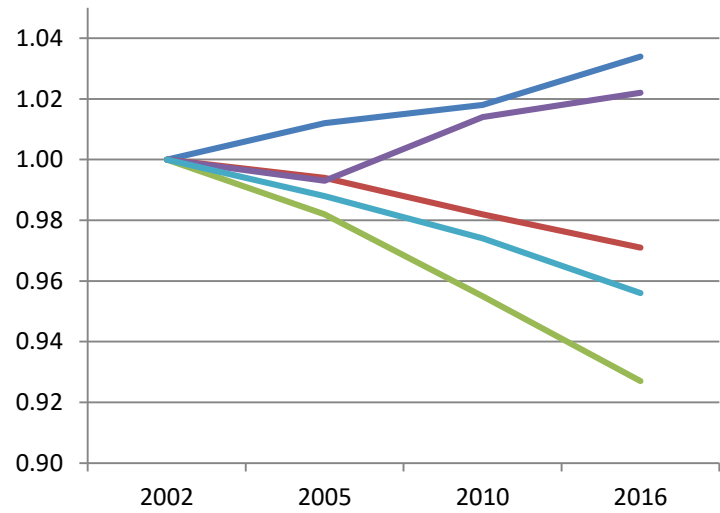


Chart 2. Dynamics of flats area per person in selected cities

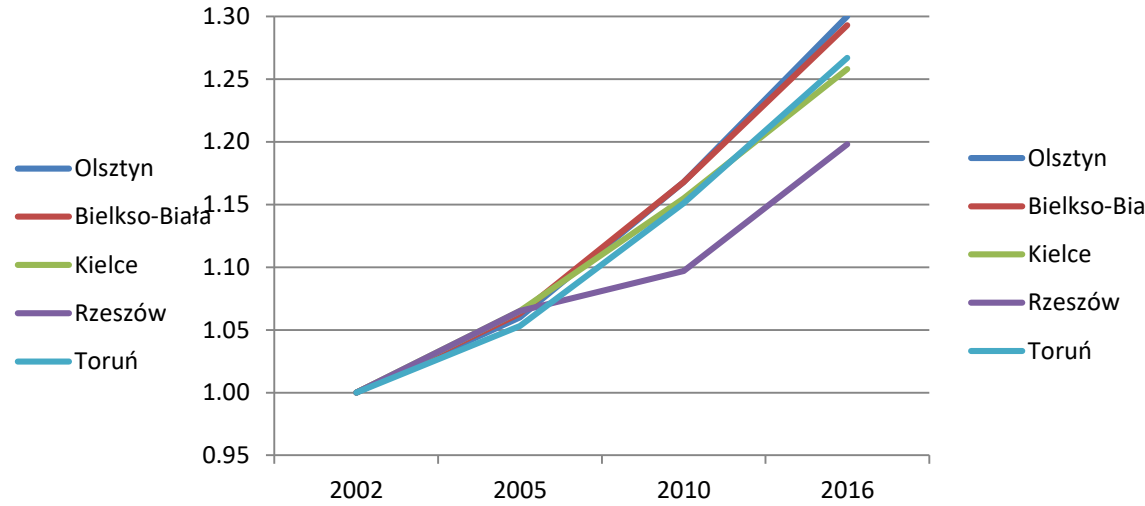


Chart 3. Dynamics of surface of the flats area in selected cities

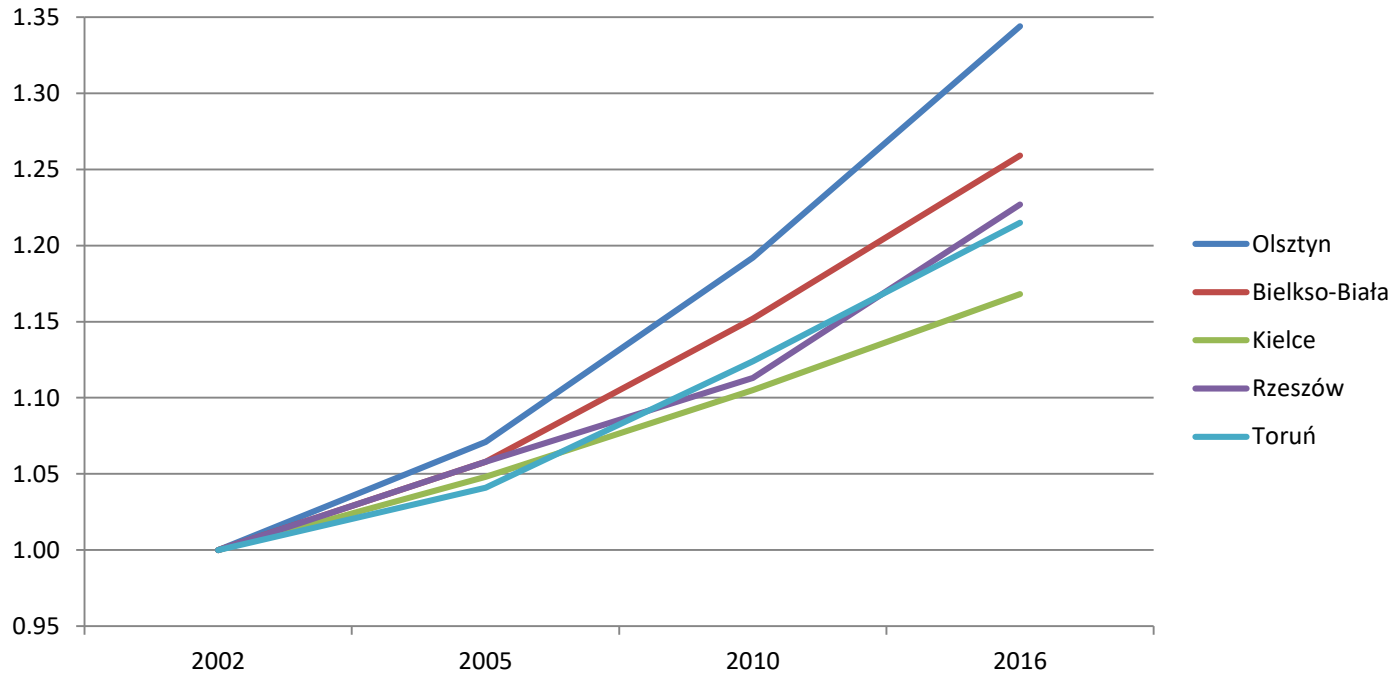


Chart 4. Dynamics of a change in population in seven municipalities

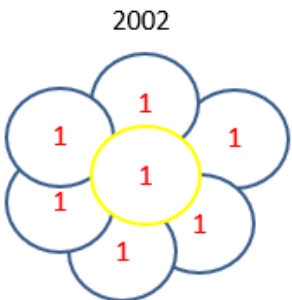
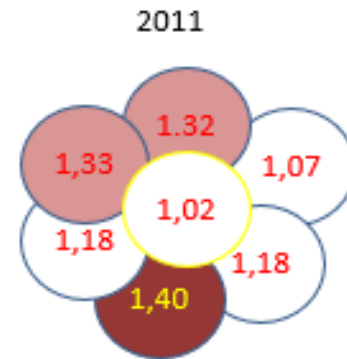
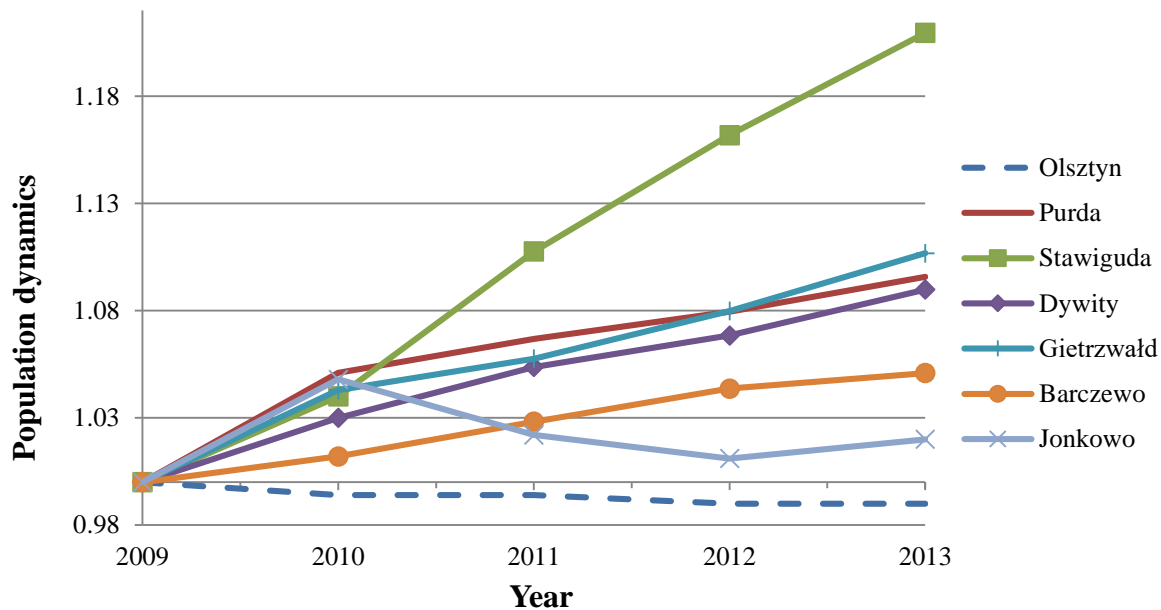
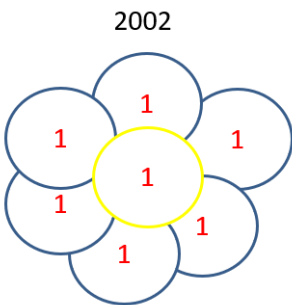
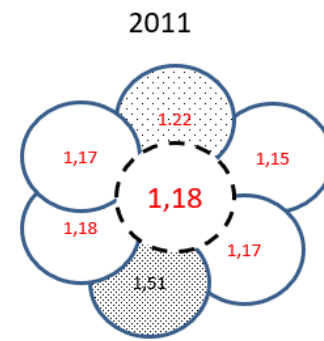
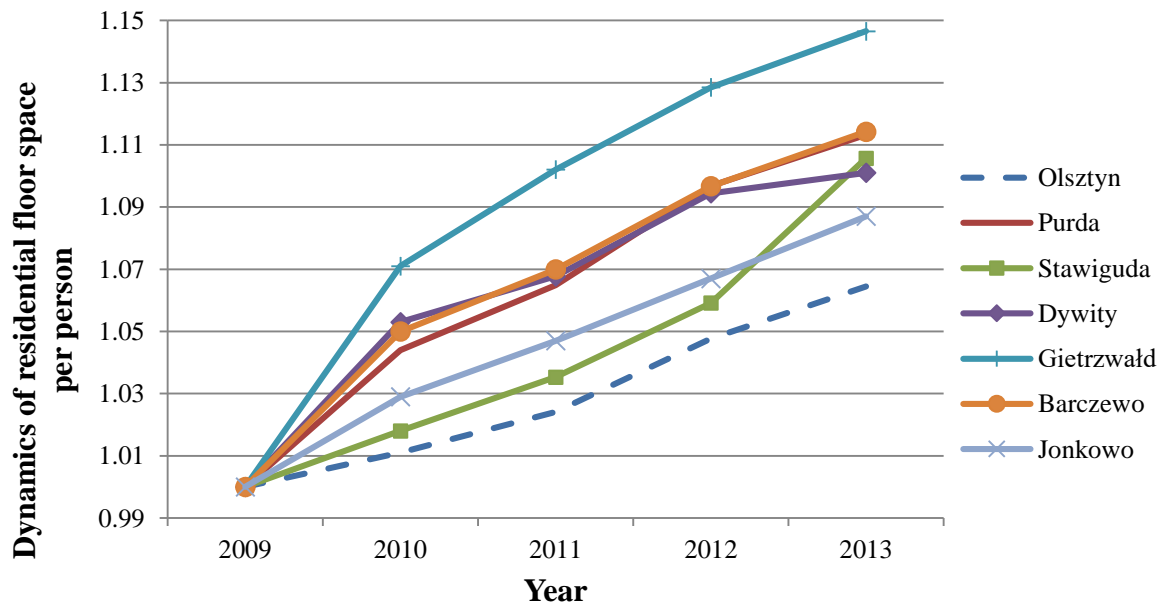


Chart 5. Dynamics of a change in residential floor space per person in seven municipalities



We can see three examples of sequences that may be created by a **population dynamics vector** and a **residential area per capita vector**.

No.	Change directions	Product as the dynamics of the phenomena
1		$\alpha_a > 0$ and $\alpha_b > 0$ a –
2		$\alpha_a > 0, \alpha_b < 0$ In the urbanised area, a process of society impoverishment has begun (emergence of slums)
3		$\alpha_a < 0, \alpha_b < 0$ $ \alpha_a > \alpha_b $ Depopulation of the city accompanied by the destruction of residential housings (occurs when cities “die”)

Source: own analysis.

Since the dynamics of two measures observed can have an opposite direction, a **spatial development dynamics indicator** (d_r) was proposed which will allow the speed of changes occurring in the areas examined to be compared.

The formula for **development dynamics** is as follows:

$$d_r = d_a^2 * d_b$$

The main subject of the paper

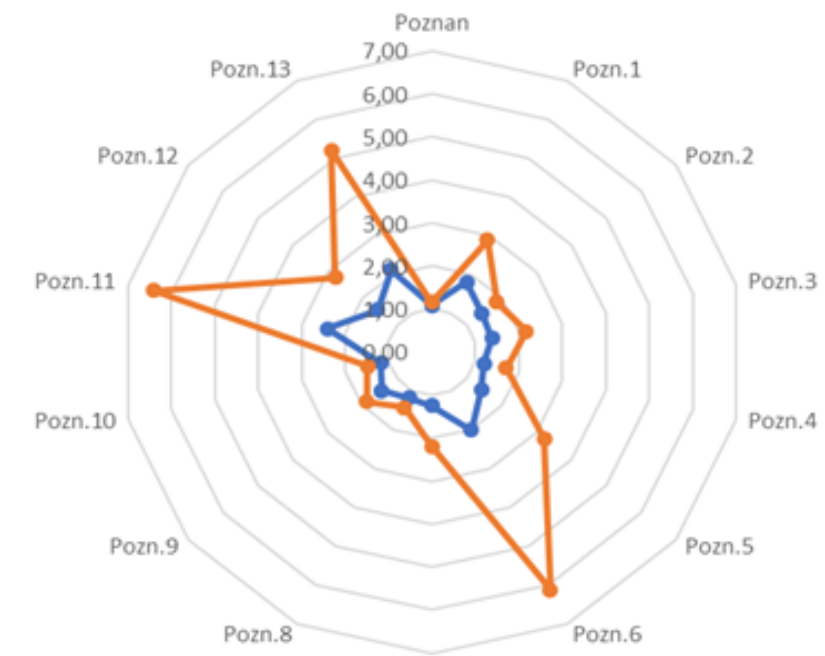
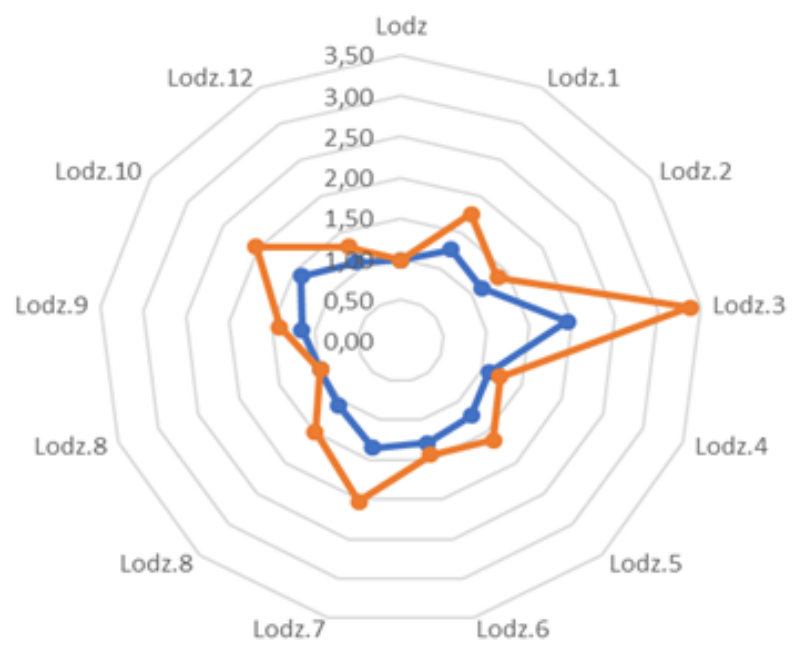
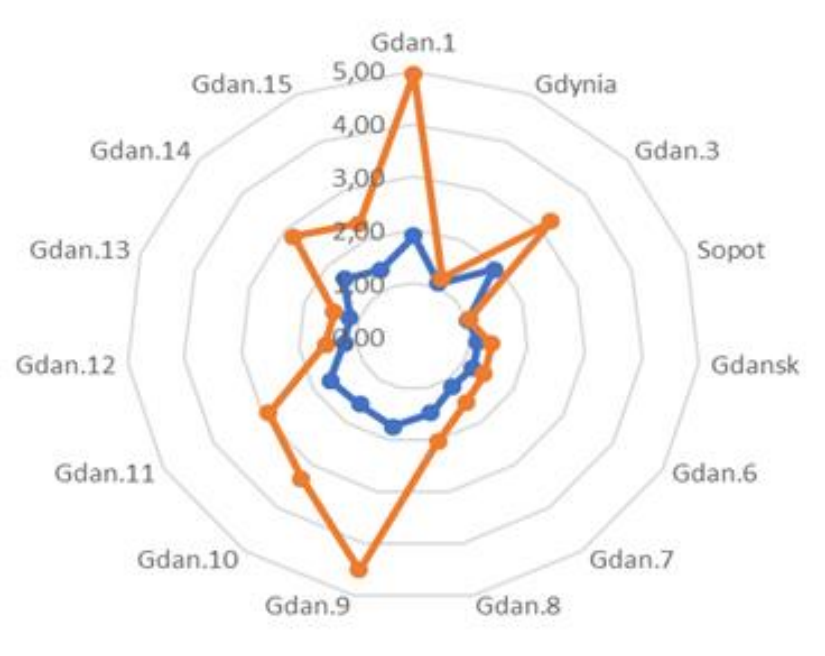
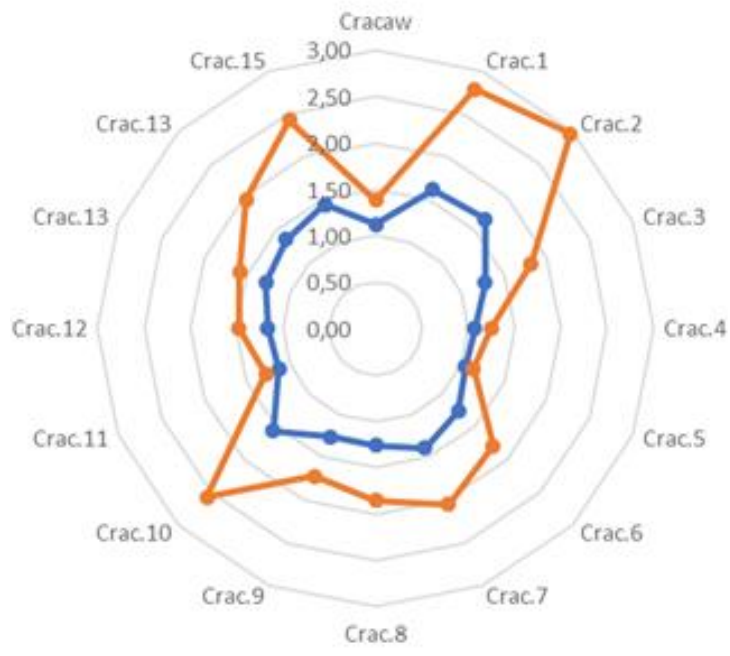
This article proposes a methodology for analysing the dynamics of urban spaces in six Polish cities which were surveyed in 2002–2016. The proposed method is based on an analysis of the trend and the intensity of changes concerning geolocation data.



The objects surveyed were characterised by similar:

- area,
- population,
- residential area

(is one exception)



Conclusion

This article proposes a method of analysing the dynamics of cities and neighbouring municipalities and communes. There is no doubt that the development analysis cannot be limited to the administrative area of a city; it must also include neighbouring municipalities and communes.

In all of the examined cases, the most important changes occur in the neighbourhood of a city. It is the impact of the central point (a city) that generates considerable changes in its neighbourhood.

- The proposed map of development dynamics allows this research topic to be analysed further in terms of the identification of **development factors**. Further studies could be based on an analysis of the correlation between the development dynamics and the variables observed in individual areas. Based on the map of development dynamics for individual cities, one may say that Poland is presently witnessing urban sprawl, which might be caused by migrations from rural to urban areas. In general, it is expected that the process of population concentration and economic activity will continue in functional zones of large cities, towns and neighbouring rural areas. This process is associated with the globalisation of the economy.

Thank you