

Analysis of changes in the land use structure of developed and urban areas in Eastern Poland

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Abstract. The development of housing, services and industry as well as the accompanying infrastructure leads to the intensification of urbanisation processes and changes in land use structure. The area of land characterised by urban use is increasing. The above trend is also observed in Eastern Poland despite its predominantly rural character and the absence of metropolitan areas exerting great pressure on the local landscape, contributing to regional development and enhancing the region's competitiveness.

The paper discusses changes in land use structure in developed and urban areas in Eastern Poland. The analysis includes five Polish voivodeships (Lubelskie, Podkarpackie, Podlaskie, Świętokrzyskie and Warmińsko-Mazurskie) characterised by the lowest GDP per capita in the EU-25. For this reason, Eastern Poland will receive aid as part of the 'Development of Eastern Poland' Operational Program 2007-2013. This is the only supra-regional program in the European Union which promotes social and economic growth in underdeveloped regions by co-financing projects in urban development, road construction and tourism promotion.

The analysis of changes in the share of developed and urban areas in total land area as well as changes in local land use structure (subgroups) covers the period of 2007-2013. The data relating to land use structure was supplied by the Head Office of Geodesy and Cartography. It was used to determine the scale and rate of urbanisation in the analysed voivodeships (regions) and their constituent poviats (counties) with special emphasis on suburban areas. The results were presented in the form of cartograms and thematic maps with the use of GIS tools. The GIS tools support the visualisation of the spatial distribution of the analysed phenomena.

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1. Introduction

Pressure from human activities contributes to the development of strongly anthropogenised areas. Urban sprawl accompanied by the development of residential, service and industrial functions as well as technological infrastructure leads to changes in land use structure. There is a continuous increase in the area of land use patterns characteristic of urban territories. This trend is also observed in Eastern Poland despite its predominantly rural character and the absence of metropolitan areas exerting great pressure on the local landscape, contributing to regional development and enhancing the region’s competitiveness.

The postulated research hypothesis states that the land use structure in Eastern Poland has been undergoing dynamic changes. The objective of this study was to describe the changes in the structure of developed and urbanised land in the evaluated region, in particular in the area occupied by transport

infrastructure. The main aim was pursued through an ancillary goal, which involved the determination of the magnitude and rate of urbanisation in the Polish voivodeships and their constituent poviats with special emphasis on suburban areas.

2. Urbanisation processes

‘Urbanisation is a complex process of change of rural lifestyles into urban ones... Nowadays, urbanisation is no longer typical for the growth of cities or towns only, but it influences the processes in the rural countryside as well’ (Antrop, 2004). Contemporary urbanisation processes are no longer confined to urban areas and transition zones, but they are also observed in typical rural areas (Szymańska, Matczak, 2002) where they lead to changes in land use structure (Fig. 1).

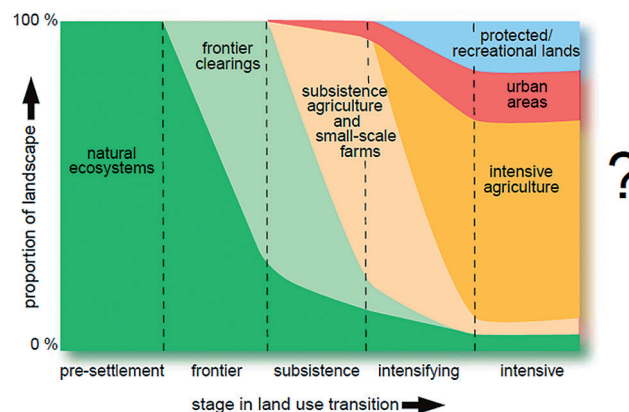


Fig. 1. Land use transitions

Source: Foley et al., 2005

Land management and land use are determined by diverse factors and processes. Various regional and local changes shape the land structure. Those changes and processes are induced by two main categories of factors – natural and anthropogenic, and changes in land use structure result from mutual interactions between people and the environment (Verburg et al., 2010). Different forms of land use evolve under the influence of social, economic, political, environmental and cultural factors (Veldkamp, Fresco, 1996; Verburg et al., 1997; Bouma et al., 1998; Lambin et al., 2001; Veldkamp, Lambin, 2001; Veldkamp, Verburg, 2004; Ewert et al., 2005; van Meijl et al., 2006; Rounsevell et al., 2006; Verburg et al., 2006; Shi et al., 2010; Dyson, 2011; Szymańska, Chodkowska-Miszczuk, 2011; Tóth, 2012; Verburg et al., 2012). Human activities contribute significantly to changes in land use structure and local landscape. The most dynamic changes are noted in urban and suburban zones. In recent years, rapid transformations have also been observed in the countryside due to immigration from nearby cities and the expansion of strongly anthropogenised areas with residential, industrial, service and transport functions where the share of natural land forms, such as agricultural land and forests, is steadily decreasing (Smętkowski, 2001; Bański, Stola, 2002; Bański, 2003; Foley et al., 2005; Ciołkosz, Poławski, 2006; Rounsevell et al., 2006; Szymańska, 2009; Urban, 2009; Dyson, 2011; Krajewski, Raszka, 2011; EU-LUPA, 2012; Matyka, 2012; Senetra, Szczepańska, 2012).

The changes resulting from progressive urbanisation are generally evaluated by demographic and economic analyses. They are also determined by analysing changes in land use structure which directly illustrate the variations in the share of different land use categories.

3. Specification of the analysed voivodeships

The study analysed five Polish administrative regions – the Lubelskie, Podkarpackie, Podlaskie, Świętokrzyskie and Warmińsko-Mazurskie Voivodeships (Fig. 2) in north-eastern, eastern and south-eastern parts of Poland.

The analysed voivodeships form a compact area that covers 32% of the territory of Poland. Their

inhabitants account for nearly 22% of the Polish population, and the region generates approximately 16% of the national GDP. The main problem in the evaluated microregion is a very low level of economic, social and territorial cohesion. Predominantly agricultural, this microregion is characterised by low urbanisation, poor technical development, low availability of infrastructure, very high levels of unemployment and migration rates (internal and international), low level of entrepreneurship and an outdated economic system. Sparse transportation network is one of the main barriers to social and economic development in the region (Kudłacz, 2006; Boni, 2007; Strategia rozwoju..., 2008; Rakowska, Wojewódzka-Wiewiórska, 2010).

The main selection criterion was the fact that the discussed voivodeships have been included in the 'Development of Eastern Poland' Operational Program (*Program Operacyjny Rozwój Polski Wschodniej – PORPW*) for the years 2007-2013. The program supports the initiation of projects promoting social and economic development.

The PORPW is the only supra-regional program of the type in the European Union. The main goal of the PORPW is to stimulate social and economic growth in Eastern Poland in line with the principles of sustainable development (*Program Operacyjny...*, 2012). The program promotes projects that support the development of research and scientific infrastructure, modernisation of municipal and regional transport systems and projects that increase the regions' attractiveness for investors and tourists. The program is financed from the European Union's Structural Funds, and reinforces other activities initiated in Eastern Poland, including the Regional Operational Program, Infrastructure and Environment Operational Program, Rural Development Program, Human Capital Operational Program and Innovative Economy Operational Program (*Program Operacyjny...*, 2012). Social consultations for the 'Development of Eastern Poland' Operational Program for the years 2014-2020 are currently under way.

The PORPW and other EU-financed programs constitute economic and political factors that can induce significant changes in land use structure. The achievement of specific operational targets may lead to direct changes in the land use patterns of urban and developed areas, including areas occupied by transportation networks.

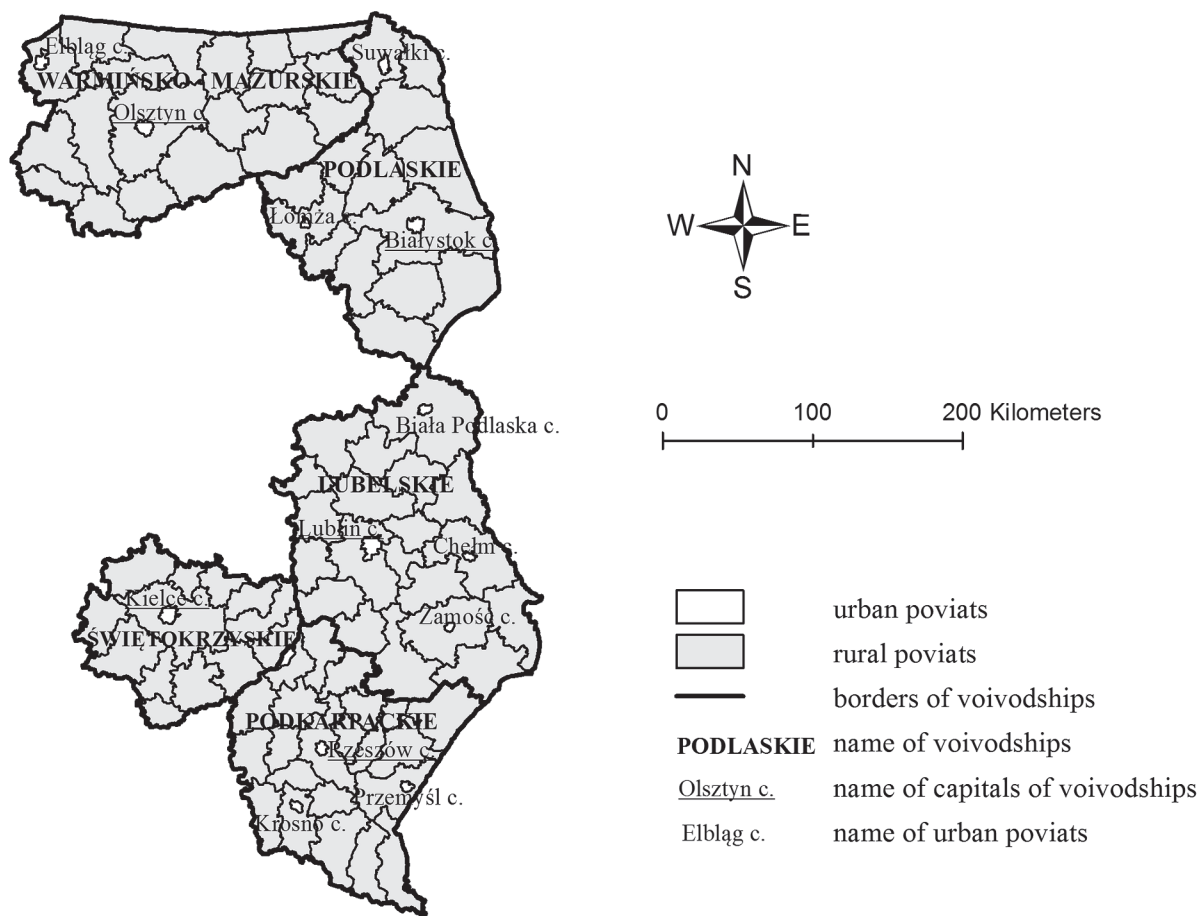


Fig. 2. The analysed voivodeships

Source: Own elaboration

4. Materials and methods

The analyses of changes in land use patterns were based on the data supplied by the Head Office of Geodesy and Cartography, which keeps the national register of geodetic and cartographic data with information about the area of land and buildings in Poland. The analysed data cover the years 2002–2013 (as of 1 January every year). The Regulation of the Minister of Regional Development and Construction on land and building registers (2001) defines the following land use categories: agricultural land, forests and land covered by trees and shrubs, developed and urbanised land, ecological sites, wasteland, water bodies and other land categories. This study analyses urban and developed areas which can be further broken down into the fol-

lowing categories: residential areas, industrial areas, other developed areas, undeveloped urban areas, recreational areas, mining areas and areas occupied by transportation networks (roads, railways, other transportation corridors).

The changes in land use structure of urban and developed areas as well as areas occupied by transportation networks, an integral part of the evaluated land-use category, were analysed with reference to the main goals of the PORPW. The transportation networks were evaluated separately as a key indicator of spatial changes and processes resulting from greater access to transport infrastructure which promotes development at different levels of administrative division.

A digital map of the analysed voivodeships was developed with a division into 87 rural poviats and 14 urban poviats as the principal research sites (Fig. 2). In Poland, the poviat is the second tier of

administrative division, and it occupies a section of the respective voivodeships (first-tier administrative unit). In the EU classification system, a powiat correspond to the NUTS 4 level.

The information obtained from statistical authorities was used to develop a database for spatial analysis. The analyses and presentations were developed with the use of ArcGIS 10 software (ESRI) which offers a comprehensive set of tools for analysing, visualising and managing spatial data.

The changes in land use patterns of urban and developed areas and areas occupied by transportation networks in the investigated voivodeships were analysed in two periods covering the years 2002-2007 and 2007-2013. The above approach was dictated by the time frame of the PORPW, and it supported a comparison of data from before the program's launch and in its last stages. The analytical process was divided into the following stages:

The database was developed for the spatial analysis of changes in the area of developed and urbanised land and land occupied by transportation networks in the surveyed sites.

The percentage share of developed and urbanised land and land occupied by transportation networks in the total area of the analysed poviats was determined.

The relative fixed-base percentage changes were calculated in the analysed periods.

The values of relative fixed-base percentage changes were referenced to the level of 100% (no change).

The digital map of Eastern Poland's voivodeships divided into poviats was developed with the use of ArcGIS 10 software.

The spatial analysis of changes in the area of developed and urbanised land and land occupied by transportation networks in the surveyed sites was performed.

The rates of changes in the analysed land use categories were presented in the form of cartograms.

5. Results

The changes in land use patterns of urban and developed areas covering the years 2002-2007 and 2007-2013 were analysed with the use of cartograms (Figs 3A and 3B), and the results are presented in Table 1. Significant differences were observed between the two investigated periods of time. The number of rural poviats where the rate of changes in land use was determined below 100% decreased from 47 in the years 2002-2007 to 10 in the years 2007-2013. The number of poviats where the change rate exceeded 100% increased from 40 in the years 2002-2007 to 77 in the years 2007-2013.

A similar trend was observed in the group of urban poviats. In the analysed periods, a negative rate of change was reported only in one powiat. The number of poviats with positive rates of change in land use increased from 9 in the years 2002-2007 to 13 in the years 2007-2013.

Table 1. Rate of changes in the area of developed and urbanised land in the analysed poviats in 2002-2007 and 2007-2013

| Rural poviats – rate of change [%] | 2002 – 2007 2002 = 100% [number of poviats] | 2007 – 2013 2007 = 100% [number of poviats] | Urban poviats – rate of change [%] | 2002 – 2007 2002 = 100% [number of poviats] | 2007 – 2013 2007 = 100% [number of poviats] |
|------------------------------------|---|---|------------------------------------|---|---|
| Below 90.1 | 25 | 1 | Below 95.1 | 3 | 1 |
| 90.1 – 95.0 | 9 | 2 | | | |
| 95.1 – 100.0 | 13 | 7 | 95.1 – 100.0 | 2 | 0 |
| Total | 47 | 10 | Total | 5 | 1 |
| 100.1 – 105.0 | 15 | 33 | 100.1 – 105.0 | 1 | 7 |
| 105.1 – 110.0 | 9 | 26 | Above 105.0 | 8 | 6 |
| Above 110.0 | 16 | 18 | | | |
| Total | 40 | 77 | Total | 9 | 13 |

Source: Own elaboration

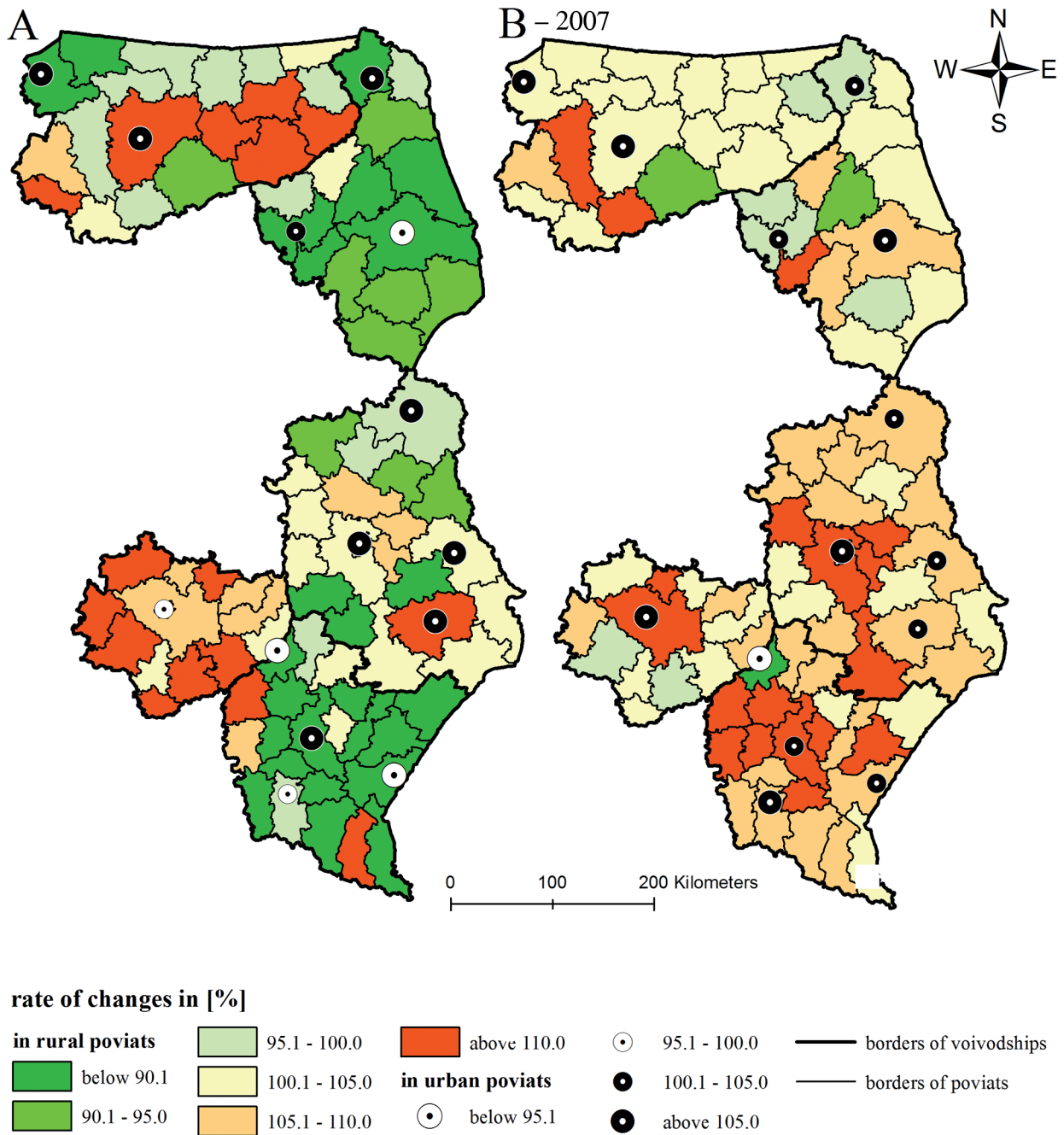


Fig. 3. Rate of changes in the area of developed and urbanized land in Eastern Polish voivodship in 2002-2007 (2002 = 100%) and 2007-2013 (2007 = 100%)

Source: Own elaboration

The changes in the land use structure of the areas occupied by transportation networks are presented in Figs 4A and 4B as well as Table 2. The results are indicative of a growth trend in the analysed voivodeships, but it was not substantial. The above can be attributed to the fact that the area

occupied by transportation networks is smaller than the combined area of developed and urbanised land. The number of rural poviats where the rate of changes in land use was determined below 100% decreased from 55 in the years 2002-2007 to 25 in the years 2007-2013. The number of poviats where the

rate of changes exceeded 100% increased from 32 in the years 2002–2007 to 62 in the years 2007–2013.

A similar trend was observed in the group of urban poviats. The number of poviats with negative

rates of change decreased from 4 in the years 2002–2007 to 1 in the years 2007–2013. In the analysed periods, the number of urban poviats with positive rates of change in land use increased from 10 to 13.

Table 2. Rate of changes in land area occupied by transportation networks in the analysed poviats in 2002–2007 and 2007–2013

| Rural poviats– rate of change [%] | 2002 – 2007 2002 = 100% [number of poviats] | 2007 – 2013 2007 = 100% [number of poviats] | Urban poviats – rate of change [%] | 2002 – 2007 2002 = 100% [number of poviats] | 2007 – 2013 2007 = 100% [number of poviats] |
|---|--|--|--|--|--|
| Below 90.1 | 8 | 1 | Below 95.1 | 2 | 0 |
| 90.1 – 95.0 | 10 | 3 | | | |
| 95.1 – 100.0 | 37 | 21 | 95.1 – 100.0 | 2 | 1 |
| Total | 55 | 25 | Total | 4 | 1 |
| 100.1 – 105.0 | 30 | 53 | 100.1 – 105.0 | 3 | 4 |
| 105.1 – 110.0 | 1 | 4 | | | |
| Above 110.0 | 1 | 5 | Above 105.0 | 7 | 9 |
| Total | 32 | 62 | Total | 10 | 13 |

Source: Own elaboration

In Table 3 the rate of land use changes in the analysed periods is expressed in terms of percentage values for rural and urban poviats and for all poviats. The analysed changes were intensified in the group of rural poviats, whereas a negative change rate was noted in urban poviats. The overall change rates for all the analysed poviats continued to increase, which can be attributed to the larger area of rural poviats and their greater contribution to the fi-

nal results. In the analysed periods, the development of many towns and cities was furthered through external funding as well as changes in their administrative boundaries. The area of several urban poviats was significantly expanded through the incorporation of the surrounding suburban zones. The above influenced the results of this survey and inhibited the formulation of reliable conclusions regarding the actual rates of change in land use structure.

Table 3. Rate of changes in the area of developed and urbanised land and land occupied by transportation networks in the analysed poviats – summary report

| Poviats | Average value of changes in urban and developed land [%] | | Average value of changes in land occupied by transportation networks [%] | |
|-----------------|--|-----------|--|-----------|
| | 2002–2007 | 2007–2013 | 2002–2007 | 2007–2013 |
| Rural | 95.1 | 105.7 | 100.2 | 101.3 |
| Urban | 105.7 | 102.8 | 110.6 | 107.2 |
| Rural and urban | 96.6 | 105.3 | 101.6 | 102.1 |

Source: Own elaboration

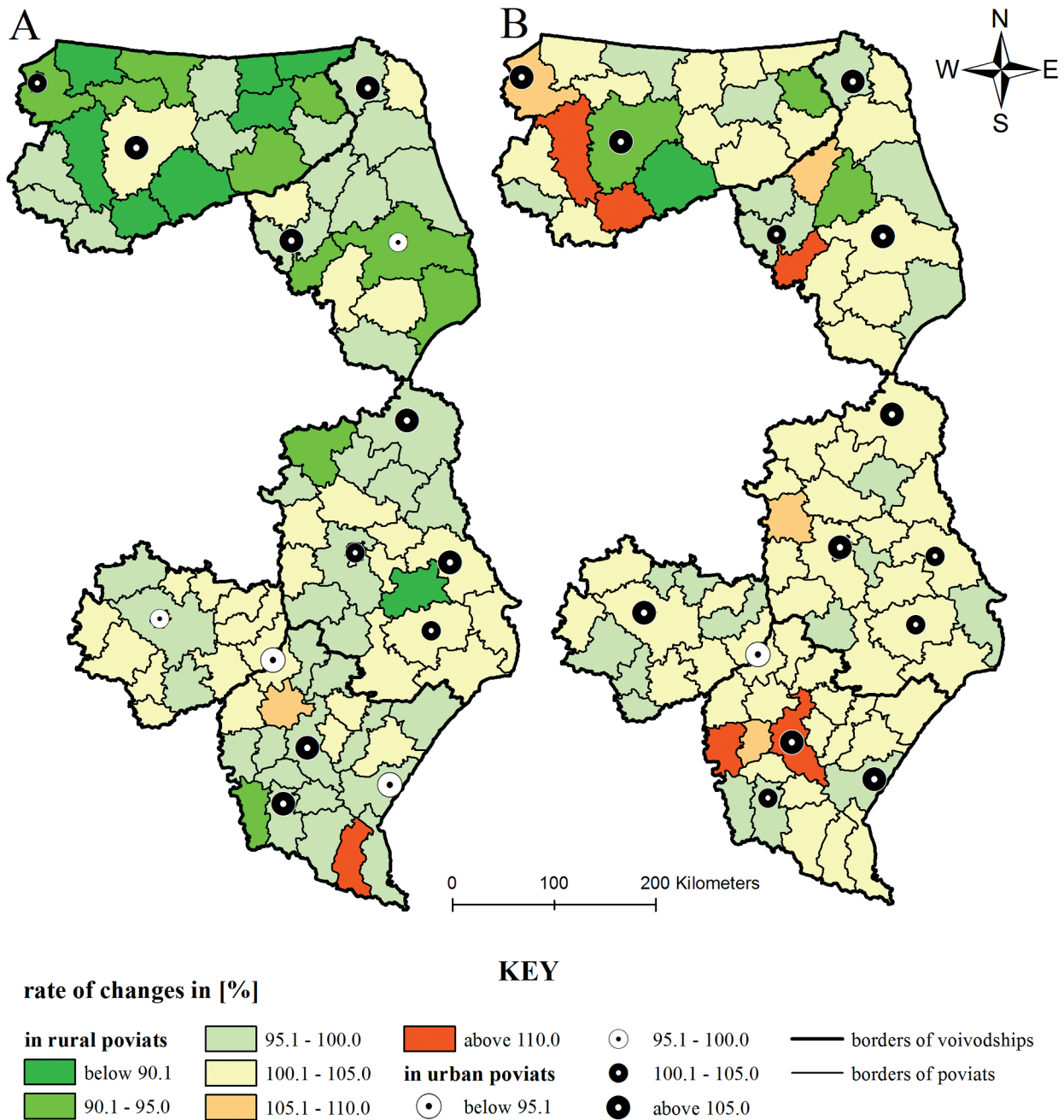


Fig. 4. Rate of changes in land area occupied by transportation networks in Eastern Polish voivodship in 2002-2007 (2002 = 100%) and 2007-2013 (2007 = 100%)

Source: Own elaboration

The area of developed and urbanised land in the eastern voivodeships of Poland is presented in Figure 5. The share of urban and developed areas decreased in the Podkarpackie and Podlaskie Voivodeships in the years 2002-2007, whereas a moderate increase was noted in the remaining voivodeships. The share of developed and ur-

banised land increased in all voivodeships in the years 2007-2013, and the rate of those changes was higher in comparison with the previous analytical period. In 2007, the area of developed and urban land in Eastern Poland decreased by 28,318 ha, but an increase of 20,000 ha was observed in the period covered by the PORPW (2007-2013).

Similar conclusions can be formulated based on Table 4 and Figure 6 which present the percentage share of developed and urbanised land and land occupied by transportation networks in every analysed voivodeships and all of Eastern Poland.

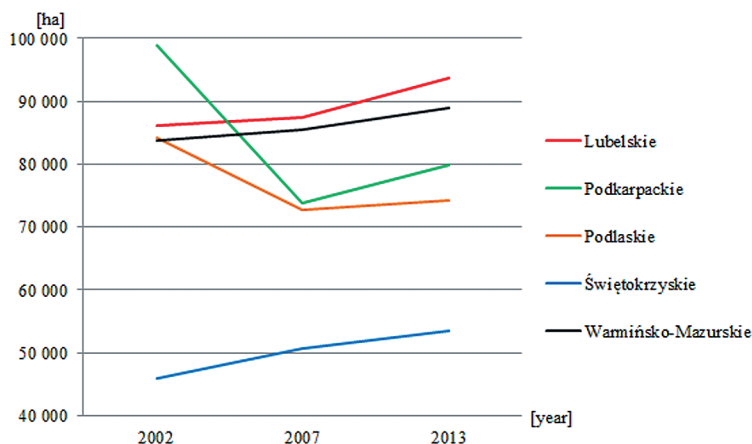


Fig. 5. The area of developed and urbanized land in Eastern Polish voivodeships in 2002, 2007 and 2013

Source: Own elaboration

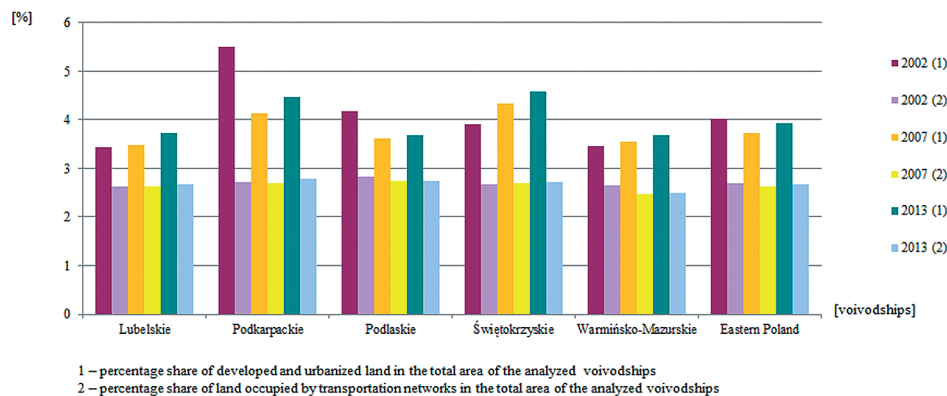


Fig. 6. Graphical representation of the share of developed and urbanised land and land occupied by transportation networks in the area of every voivodeship and in all of Eastern Poland in 2002, 2007 and 2013

Source: Own elaboration

Table 4. Share of urban and developed areas and areas occupied by transportation networks in every analysed voivodeships and in all of Eastern Poland in 2002, 2007 and 2013

| Voivodeships | 2002 | | 2007 | | 2013 | |
|---------------------|------|------|------|------|------|------|
| | 1 | 2 | 1 | 2 | 1 | 2 |
| Lubelskie | 3.43 | 2.62 | 3.48 | 2.62 | 3.73 | 2.68 |
| Podkarpackie | 5.51 | 2.71 | 4.14 | 2.70 | 4.47 | 2.78 |
| Podlaskie | 4.17 | 2.82 | 3.61 | 2.73 | 3.68 | 2.73 |
| Świętokrzyskie | 3.92 | 2.67 | 4.34 | 2.69 | 4.58 | 2.72 |
| Warmińsko-Mazurskie | 3.46 | 2.66 | 3.54 | 2.48 | 3.68 | 2.50 |
| Eastern Poland | 4.02 | 2.69 | 3.74 | 2.63 | 3.94 | 2.67 |

Explanation: 1 – percentage share of developed and urbanised land in the total area of the analysed voivodeships; 2 – percentage share of land occupied by transportation networks in the total area of the analysed voivodeships

Source: Own elaboration

6. Conclusions

The results of this survey point to a positive rate of changes in the structure of developed and urbanised land and land occupied by transportation networks. The noted increase could have been stimulated by the 'Development of Eastern Poland' Operational Program. In the evaluated period, the area of the analysed land categories increased in most voivodeships, in particular in the period covered by the PORPW (2007-2013) and the associated projects, including the Regional Operational Program, Infrastructure and Environment Operational Program, Rural Development Program, Human Capital Operational Program and Innovative Economy Operational Program.

The trends observed in Eastern Poland are similar to the change processes noted across the entire country. In the years 2004-2009, the mean annual increase in the area of developed and urbanised land was estimated at 1.01% (Wierchowiski, 2009).

In the years 2002-2007, a decrease in the area of developed and urbanised land was reported in the Podkarpackie and Podlaskie Voivodeships. The noted decrease could be explained by the following processes: (a) significant increase in the area of forests and land covered by trees and shrubs, and in the Podkarpackie Voivodeship – also an increase in the area of agricultural land; (b) updating of the land and building register, which resulted in the classification of selected areas as agricultural land. The above applies particularly to farm roads that had been erroneously classified as transportation networks; (c) reclamation of exploited mines for agricultural and afforestation purposes; (d) decrease in areas occupied by railroads following the closure of many railroad lines. The above led to the elimination of the associated infrastructure and the reclamation of selected areas; (e) housing cooperatives and municipal authorities became the legal administrators of district and internal roads. Those roads presently constitute part of residential estates and are not classified as transportation networks. The above lowered the growth rate of areas occupied by transportation infrastructure.

The changes in land use structure are not only observed in the evaluated voivodeships but also in the analysed time periods. They result mainly from

internal attributes that condition the development of the investigated administrative units. For example, the Podlaskie Voivodeship is a typical agricultural region, and the growth rate of areas occupied by transportation networks is relatively low. In the Warmińsko-Mazurskie Voivodeship, the main areas of economic activity are agriculture and the tourist industry, which explains a somewhat higher rate of changes in land use structure. Major urban centres can also significantly contribute to the discussed changes. The city of Lublin (Lubelskie Voivodeship) has been classified as a metropolitan area in accordance with the National Spatial Development Concept 2030.

The results of this study lay the foundations for further, more detailed research. In this survey, the data at the powiat level were acquired and analysed. The majority of analyses of the type are performed at the regional level, which produces a highly generalised picture of changes in different parts of the investigated voivodeships. The used approach, however, supports the identification of problem areas and underdeveloped areas, and facilitates the development of recovery programs for poviats characterised by stagnant growth.

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