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The main processes responsible for landscape transformation in post-industrial urban areas in Central Europe

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Abstract

In recent years, the dynamic of spatial change has been increasing, influenced by processes linked to the transformation of traditional industrial regions into metropolitan areas. This is related to changes in function and administrative status, but above all to spatial changes. Examples of cities experiencing dynamic landscape changes from coal mining cities to modern metropolises can be found in the former coal basins of Central Europe – the Upper Silesian Metropolis in Poland and the Ostrava-Karviná Region in the Czechia. This study analysed the transformation of the landscape on the basis of land cover data from the years 2000, 2006, 2012 and 2018. The index of landscape change and the index of change of individual cover types were calculated, and on the basis of these indices the main processes responsible for the transformation of the landscape were determined. In the two study areas, similar changes in the landscape are taking place but at different rates. The main processes changing the landscape are suburbanization, reindustrialisation and agricultural land abandonment. In space, they are manifested in an increase in the areas of residential, commercial and service development, the densification of the road network, and an increase in land allocated for new industrial plants. At the same time, the acreage of agricultural land (mainly arable fields, orchards and plantations but also open landscapes) is decreasing.

Keywords:
landscape changes, suburbanization, metropolization, spatial chaos, transition from coal

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1 Introduction

Influenced by dynamic economic, political and demographic but also environmental changes, the landscape is changing rapidly (Ellis et al, 2013). With each successive phase of civilizational development, the transformation of the landscape proceeds at an ever-increasing pace (Foley, 2005, Turner et al 1990). New ways of life, the high demand for products and services and the expectation of a life of abundance and material prosperity contribute significantly to this change. All this generates the need for the production of goods, their transport and their proper distribution (Douglas and Isherwood, 2021). On the other hand, human beings living in rapidly changing world still need to be in a clean, healthy environment with high ecological values (Peattie, 2010; Nguyen et al, 2019, Pukowiec-Kurda, 2022). Such a construction of the contemporary world generates, on the one hand, dynamic transformations of the landscape and, on the other, the need to protect those fragments of it, which bear valuable features (Kareiva, 2007). This state of affairs poses a difficult research task in the field of landscape planning and management (Liu et al, 2018). Furthermore, it clearly indicates the need for sustainability in acting for the benefit of the environment, the economy and society.

The dynamism of landscape transformation is very evident in places where man as the main agent of change exerts particularly high pressure (Antrop, 2000). These places are primarily cities, especially large ones in terms of population (Güneralp and Seto 2013; Seto et al, 2012). The most populated cities are often cities connected with industry and also cities that have the industrial transformation behind them, but their genesis is closely connected with industry (Liu et al, 2018). Examples include the large coal mining districts where metropolitan areas now operate, such as the Ruhr and the Saarland in Germany, the Northern Coalfield in France, the Middle England area or the Ostrava and Upper Silesian coalfields (Myga-Piątek et al, 2020, Bajgar et al., 2019). The latter two are unique in that they are located relatively close to each other, about 100 km apart, and on the territory of two countries – Poland and the Czechia. Industrial basins were most often established as coalfields as early as the 18th century in England, and in the rest of Europe mainly in the 19th century (Philbeck and Davies, 2019). They developed demographically as nuclei attracting people to work. They gave rise to large cities and later their agglomerations, some of which now have metropolitan status. Each stage of their development is characterized by a common issue – the dynamics of spatial transformation (Inostroza and de la Barrera, 2018). Research on the transformation of the landscape of such urban centres is necessary and timely because nowadays in Central Europe they are currently undergoing the greatest transformation yet during their transition from traditional industrial districts to metropolitan areas (Kijowska et al, 2010, Pukowiec-Kurda and Vavrouchova, 2020).

The study of the transformation of urban landscapes is being undertaken by many researchers from different disciplines (Artmann et al, 2019; Dadashpor et al, 2019; Aguilera et al, 2011; Weng, 2007; Cieślak, Biłozor, 2022). The main streams of research in this area include studies of contemporary urban transformation and studies of cities during the period of industrialization, but academics have paid special attention to changes in space in former post-socialist cities (Spórna and Krzysztofik, 2020; Sroka et al., 2019). Studies on this topic are mainly concerned with Central and Eastern Europe, although they are conducted by researchers from various centres. Also noteworthy is the research conducted in cities undergoing transformation after the transition from industrialization to service provision (Martelozzo et al 2014). This aspect concerns cities of former industrial districts, especially traditional industries – coal, steel and machinery. Traditional resource management in this study is understood as basing the economy on the mining and metallurgical industries. These are considered old-style industries, traditionally and technologically dating back to the industrialization era, based on raw material resources and simple mining and processing technologies. In contrast, new-technology industries are based on hi-tech knowledge and technology. Many researchers have written about this issue (Gwosdz, 2014, Tkocz 2015). An equally important aspect is the impact of the transformation of the landscape of cities and suburban zones on ecological values and ecological functions (Pukowiec-Kurda, 2022, Rolf, 2021).

The landscapes of post-industrial regions are changing at a rapid pace. They are being supplemented and enriched with new elements, spaces, types and forms of land use but often to the detriment of the ecological value. This is mainly the result of the processes associated with dynamic urban sprawl (Behnisch et al 2022). In the suburbs, but also inside cities or their agglomerations, new residential neighbourhoods are being created and equipped with adequate infrastructure and services (Ewing, 2008). The rapid pace of these processes often leads developers to skip the planning stage when constructing such spaces. They are created haphazardly, without analysis of their further impact on the landscape or the functional and ecological structure of the entire city. This is due to the fact that in some Central European countries, planning documents and regulations are quite variable and subject to interpretation (Śleszyński et al., 2021). The result is development of the economic and infrastructural aspects of the city accompanied by spatial disorder and a reduction in ecological value (Travisi et al, 2010). To properly understand the mechanisms involved and their dynamics, it is necessary to check the factors underlying their formation and calculate them quickly. Therefore, the aim of this article is to determine the degree of landscape transformation in the post-transition period (2000–2018) and to identify the main processes responsible. Due to the adopted research area, the diagnosed processes and transformations taking place are characteristic of the Central Europe area.

2 Materials and methods

2.1 Study area

The study area comprises two agglomerations with similar origins based on coal mining – the Silesian Metropolis (GZM) in Poland and the Ostrava-Karvina Region (OKR) in Czechia. They are located about 80 km from each other in the same historic Silesian region and are connected by the A1 motorway. The selected research areas are similar in several aspects. Both are industrialized areas with their origins in coal mining (Dulias, 2016). Both are centred on similarly sized, major multifunctional cities (Katowice and Ostrava) that have been undergoing a process of spatial

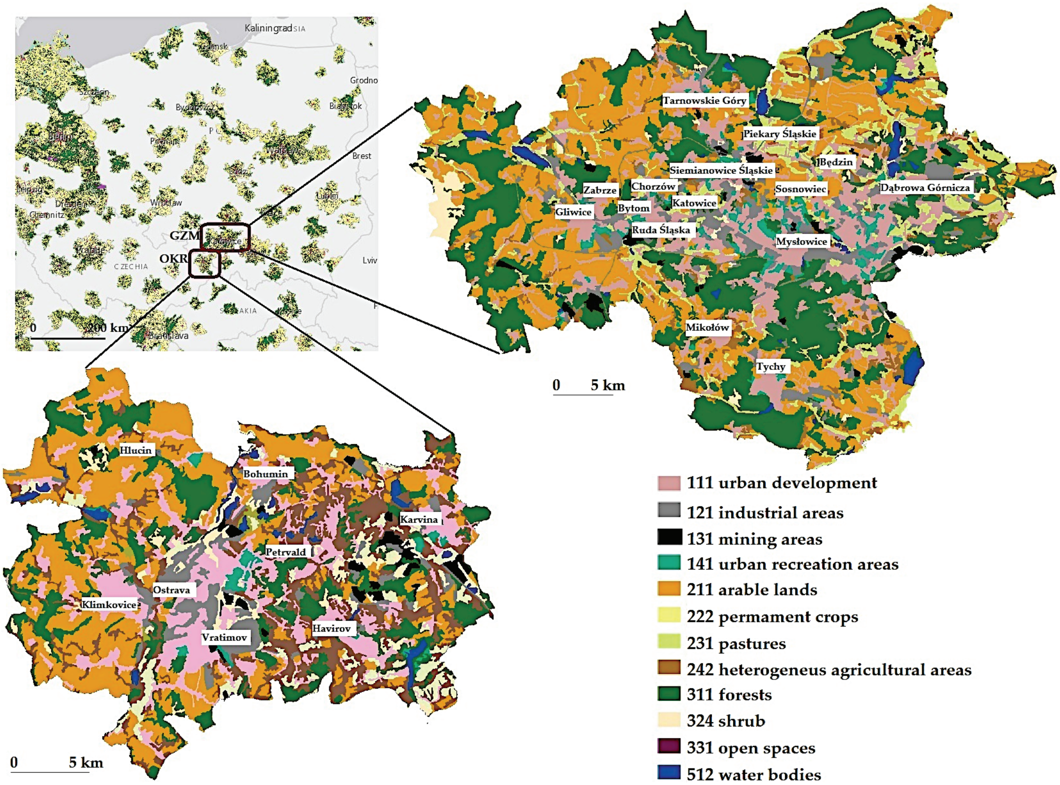

Figure 1. Localization of study area with land cover types (own elaboration based on Urban Atlas and Corine Land Cover 2018).

transformation since the 20th century (Chmielewska, 2016; Mulkova et al., 2012). Nevertheless, they also have several differences, which are primarily due to their location within the territory of two different countries with two different ways of managing the landscape. The Silesian Metropolis contains 41 municipalities and covers an area of almost 2500 km^2, while the Ostrava-Karvina Region contains 22 municipalities covering an area of 620 km^2. The population of the GZM is almost 2.25 million residents, while in the OKR it is almost 0.95 million residents. In both agglomerations, the dominant cover types are built-up areas, forests and arable land (and, in the Ostrava-Karviná agglomeration, additionally shrub vegetation), each of which occupies more than 20% of the total area. The industrial and mining developments that are so characteristic of both study areas occupy a substantial proportion of the land in each agglomeration (Pytel et al., 2021) (Fig 1.).

As for the administrative status of the study areas, it is worth noting that the GZM has the status of a metropolis, the first and, so far, the only one in Poland, established on January 1, 2017 (Pukowiec-Kurda, Vavrouchowa, 2020). On the other hand, the OKR in Czechia is defined as an urban functional area (Popelkova, Mulkova, 2018). In addition, both study areas partially overlap with the former industrial districts through which they developed: the GZM with the Upper Silesian Industrial District, with its capital in Katowice, and the OKR with the Ostrava-Karviná Mining District, with its capital in Ostrava (Paci, Usai, 2000).

2.2 Materials

The primary research material for landscape transformation analysis is the Corine Land Cover (CLC) - land cover database being produced under the project of the same name. The European Environment Agency (EEA) is responsible for coordinating the project (Corine Land Cover, 2022). The CLC is divided into three levels of detail, with each successive level being more accurate (Cieślak et al. 2020). The entire database contains five major coverage types in level 1, 15 land cover forms in level 2, and 44 land cover classes in level 3, the most detailed level of the study (Corine Land Cover, 2022).

In addition, orthophotos of the OKR and GZM from the beginning of the study period (2000) and the end of 2018 were used as supporting materials. Orthophotos were used as WMS (Web Map Service) data through GIS software. WMS is provided by the geoportals of Poland and the Czechia, as well as the regional geoportal of the GZM–ORSIP. The research materials also included photographic documentation and notes from fieldwork, which took place from 2017 to 2022.

2.3 Methods

The work within this article is the first part of a larger research concept carried out as part of a scientific project (Fig. 2). The methodology for this project is based on the existing LUCC model (Turner et al., 1995; Brown et al, 2012) but supplemented with a landscape type (LTC) analysis. The model has been named LUCC+LTC (Land Use Cover Changes + Landscape Type Changes). In the first stage of this study, on the basis of the CLC, the degree of land use change (the dynamics of change, as well as its directions) from 2000 to 2018 was analysed, and at the same time the identification and typology of landscape units was carried out. In the second stage, based on the results obtained from the analyses of the first stage, the main landscape processes and their locations were diagnosed. In selected loca-

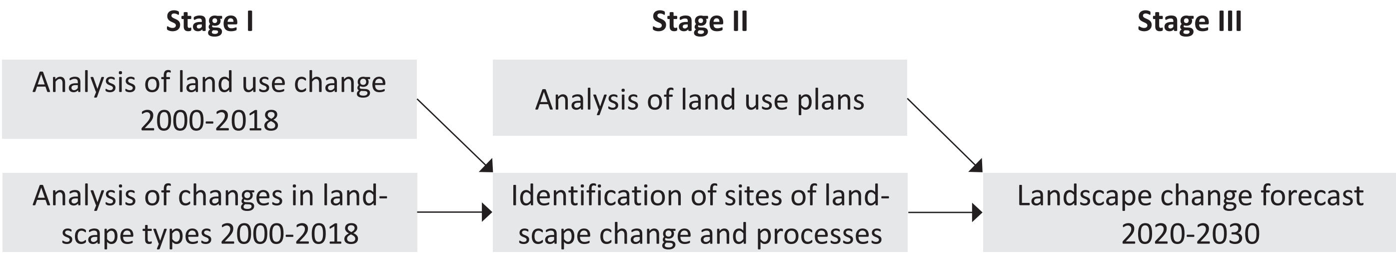

Figure 2. Methodology for determining the main directions of landscape transformation with a forecast. Note: This article presents the results of stage 1 (own elaboration).

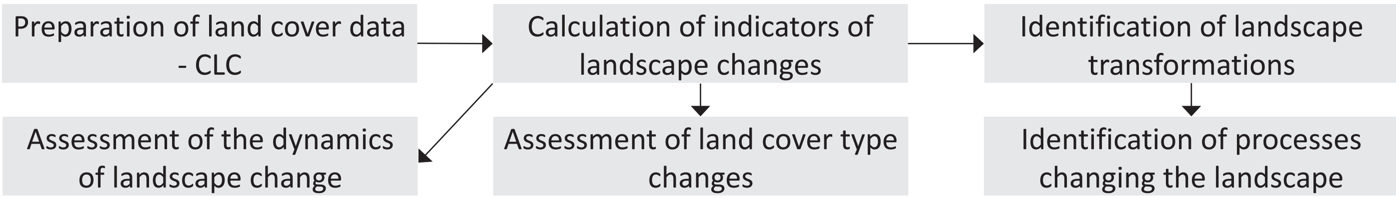

Figure 3. Methodology with several steps of investigation of Land Use Cover Changes (LUCC) (own elaboration).

tions, local land use plans were revised to determine the directions of further transformation (stage III).

This article contains the results of part of the first stage of the whole methodology (Fig. 2) of the entire project – the LUCC (Land Use Cover Changes) analysis. Nevertheless, the LUCC study methodology had also several steps of investigation (Fig. 3). The research methodology is built on the logical principle of general to specific, with each successive steps providing more detailed and accurate data (Fig. 3).

The first step involved a general analysis of land cover, the area occupied by it and changes within it (Fig. 3). In the second step of the study, the ICh index of landscape change was calculated, which determines the percentage of land that underwent transformations (Vavrouchová, Toman, 2013). On this basis, it was determined how much transformation was taking place, and the compilation of the results of the index in time sequences made it possible to study the dynamics of landscape transformation. The indicator was used repeatedly in various test areas. Its mathematical form is as follows:

$$ICh_{(ab)} = \frac{\Sigma_{i-1}^{n} | r_{ib} - r_{ia}}{2c} \times 100$$

where: ICh (ab) – index of change in period between year a and b

n – number of land use types

r_{ia} – area of type x in year a

r_{ib} – area of type x in year b

c – total area of municipality

In the third step of the study, a second indicator was used to determine changes within each coverage type (Šveda, 2010). The analysis of changes in all coverage types for both areas as a whole, as well as for each municipality separately, was performed using statistical and mapping software. The land cover classes that had undergone the greatest change were selected for further analysis. Based on a comparative analysis of the CLC database and the orthophotos, it was determined which coverage types had transformed and what type they had become. The formula for the index that determines the changes in each land cover type is as follows:

$$IRCh_{(ab)} = \left(\left(\frac{r_{ib} \div r_{ib}}{r_{ia} \div r_{ia}}\right) \times 100\right)$$

where: IRCh – index of relative change of selected land use types

ria – area of land use type x in year a

rib - area of land use type x in year b

cia – total area of municipality in year a

cib - total area of municipality in year b

The fourth step of the study was effectively an interpretation, as it was based on the results of analyses from previous steps. On the basis of selected modes of transformation of land cover types, the main processes responsible for landscape transformation were identified. On the basis of the identified processes, an author's map showing landscape transformation processes in post-industrial city areas was developed.

MapInfo Pro 2019 and ArcMap 10.5 software were used to develop cartographic maps, while Excel was used to calculate indicators and develop charts. The field phase involved preliminary identification of landscape transformations visible in the field, which took place in 2017 and 2018, and in the following years (2019–2022) photographic documentation and verification of sites diagnosed in the mapping analysis as potentially transformed were performed.

3 Results

3.1 Land Cover Type Changes

In the area of the Polish GZM metropolis over the 18-year period studied from 2000 to 2018, it was noted that the area of urban development (111) increased by as much as 3% (Fig. 4). Other areas that increased included industrial, urban recreational, water and pasture areas. In each case, this was by a value of 1%. The type of coverage that did not change was forest land, which accounted for 28% of the GZM's area. The largest decrease in area was in arable fields, which decreased by 4%. Mining land (1%), diversified cropland (1%) and shrub (1%) also declined.

In the area of the Czech OKR, an increase was noted within the study period (2000-2018) in the areas of urban development, industrial development and forests, but only by 1% (Fig. 5). Mining areas, recreational areas, pasture, heterogeneous agricultural areas, shrubs and bodies of water did not change in the 18 years studied. Only the area of cultivated fields decreased by 3% relative to the beginning of the study period.

In general, fewer cover types changed in the OKR than in the GZM, and these changes had a smaller spatial extent. Changes in land cover types were similar in both study areas: an increase in urban development areas (+), an increase in industrialised areas (+), a decrease in coal mine areas (-), and a decrease in areas of arable fields (-), with greater percentage changes observed in the GZM. In the GZM, almost all land cover types changed; in the OKR some of them remained constant during the studied 18 years.

3.2 Index of Landscape Changes and Landscape Dynamics

The dynamics of landscape change were calculated using the Index of Landscape Change (ICh) over the entire study period and individual sub-periods. The results obtained indicate that three times more landscape change occurred in the GZM (ICh 2000–2018=6.36) than in the OKR (ICh 2000–2018=2.42). The three phases of landscape change (dynamic growth, major landscape changes and slowing down phase) can be distinguished in the GZM, while in the OKR there was a continuous reduction of landscape changes throughout the study period (Fig. 6).

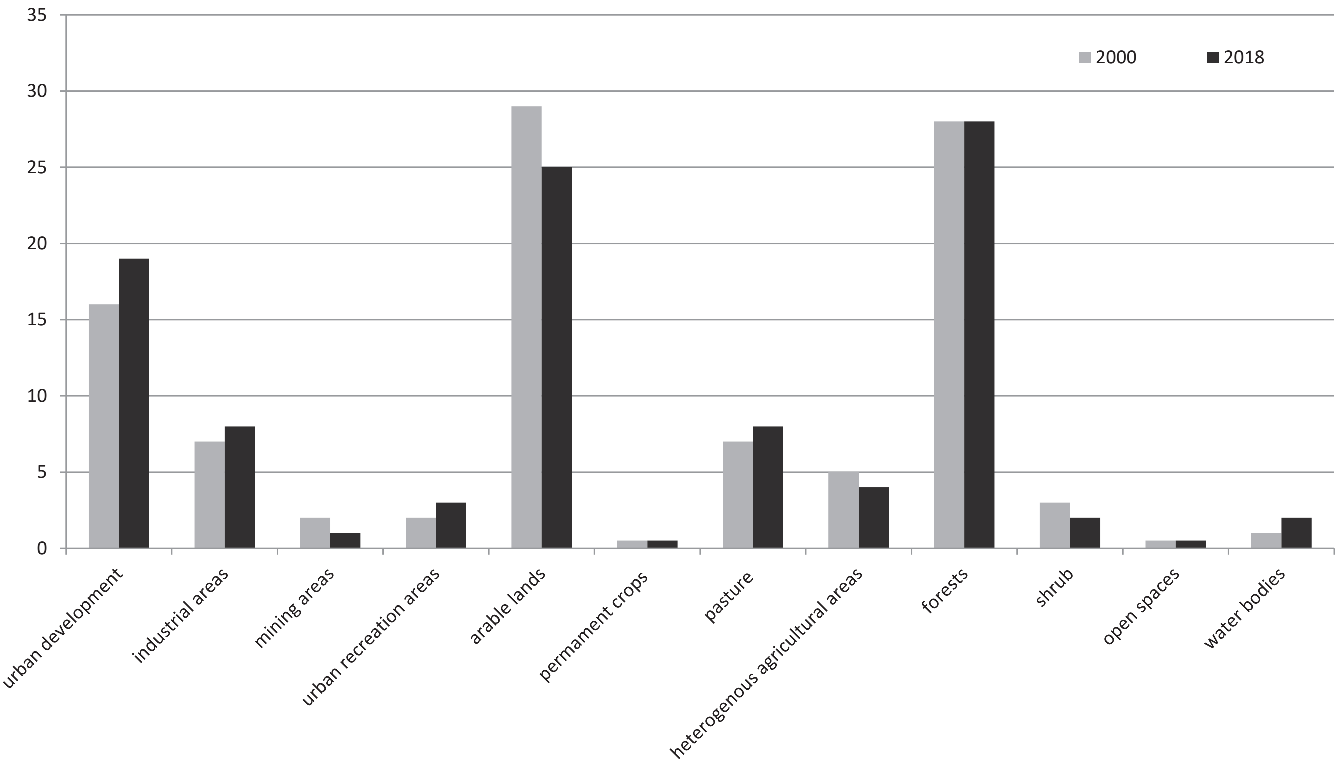

Figure 4. Land Cover Types in Silesian Metropoly in 2000 and 2018 (own elaboration). Note: The „+“ sign indicates types of coverage whose areas have increased, while „-“ indicates types that have decreased relative to 2000.

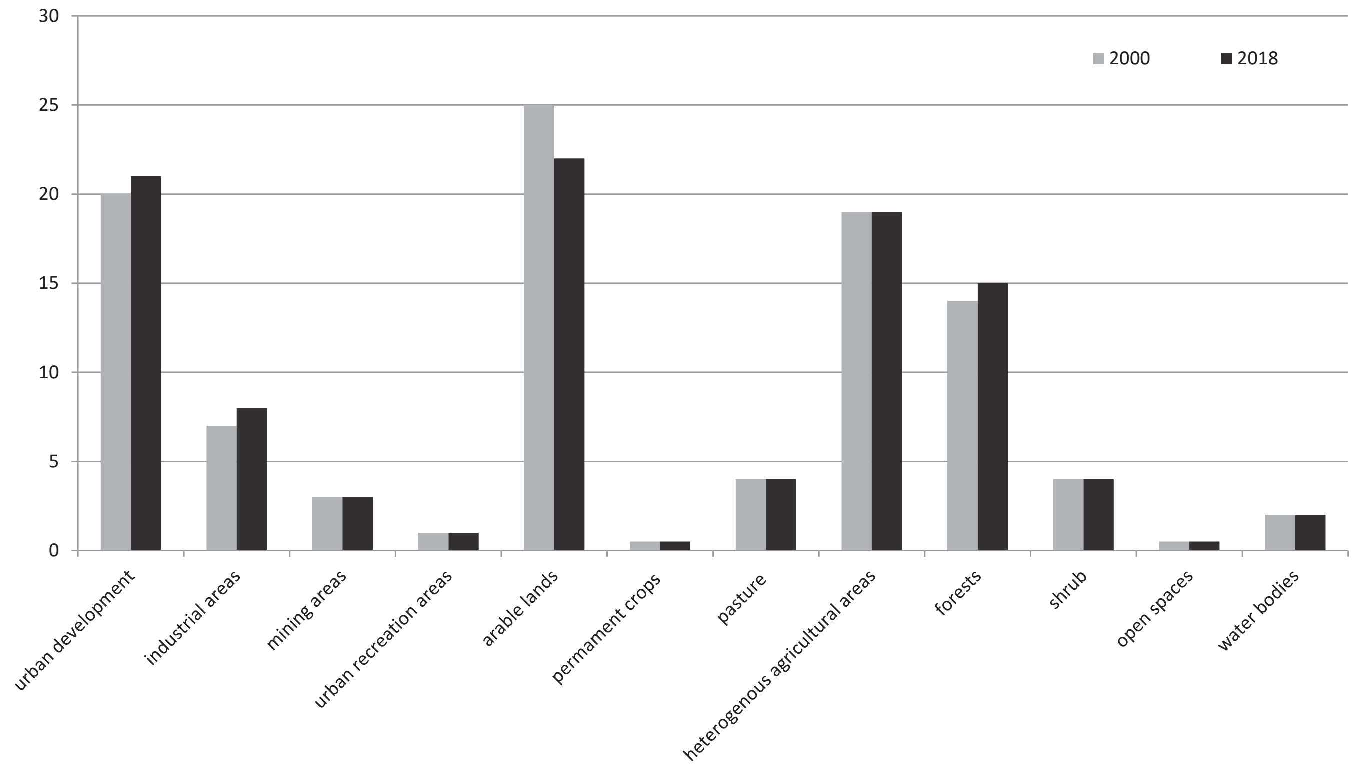

Figure 5. Land Cover Types in Ostrava-Karvina Region in 2000 and 2018 (own elaboration). Note: The „+" sign indicates types of coverage whose areas have increased, while „-" indicates types that have decreased relative to 2000.

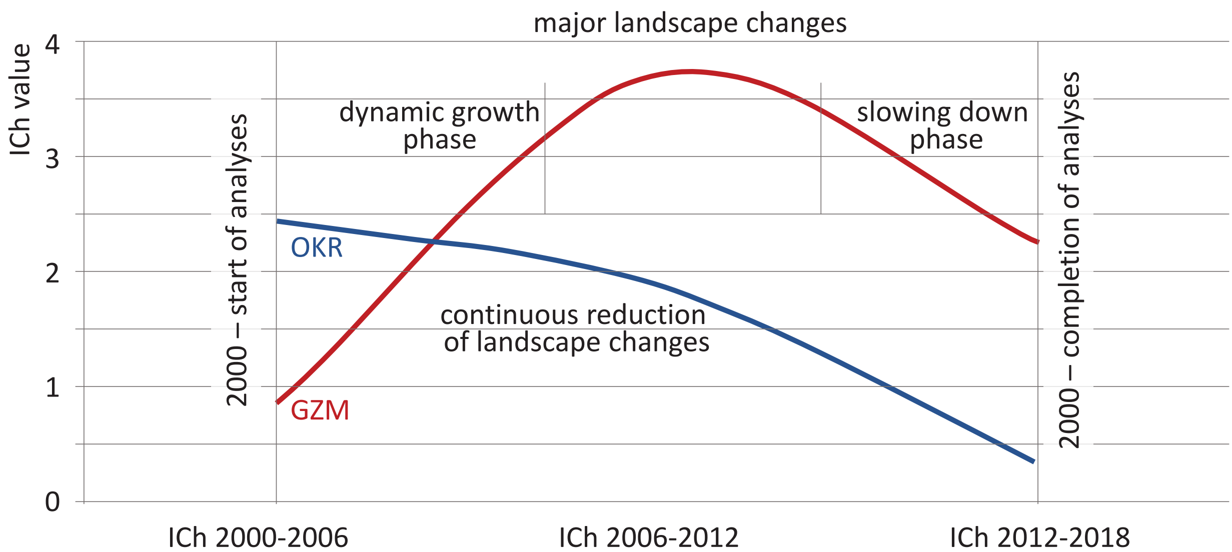

Figure 6. Dynamics of index of landscape changes (ICh) in GZM and OKR (own elaboration).

3.3 Index of Relative Change of Selected Land Use Types

The index indicated the general trends of transformation within each coverage type throughout the study period and in the designated three sub-periods. In the GZM area, industrialization, overgrowth of agricultural land (natural succession) and an increase in water surface area were observed. The losses of certain cover types indicate the disappearance of mining areas, agricultural areas (orchards and plantations) and open landscapes. These changes did not all occur throughout the entire period studied, and some were characteristic of its sub-periods. Between 2000 and 2006, there was a rapid disappearance of mining areas while water areas increased. In the middle period of 2006–2012, the increase in

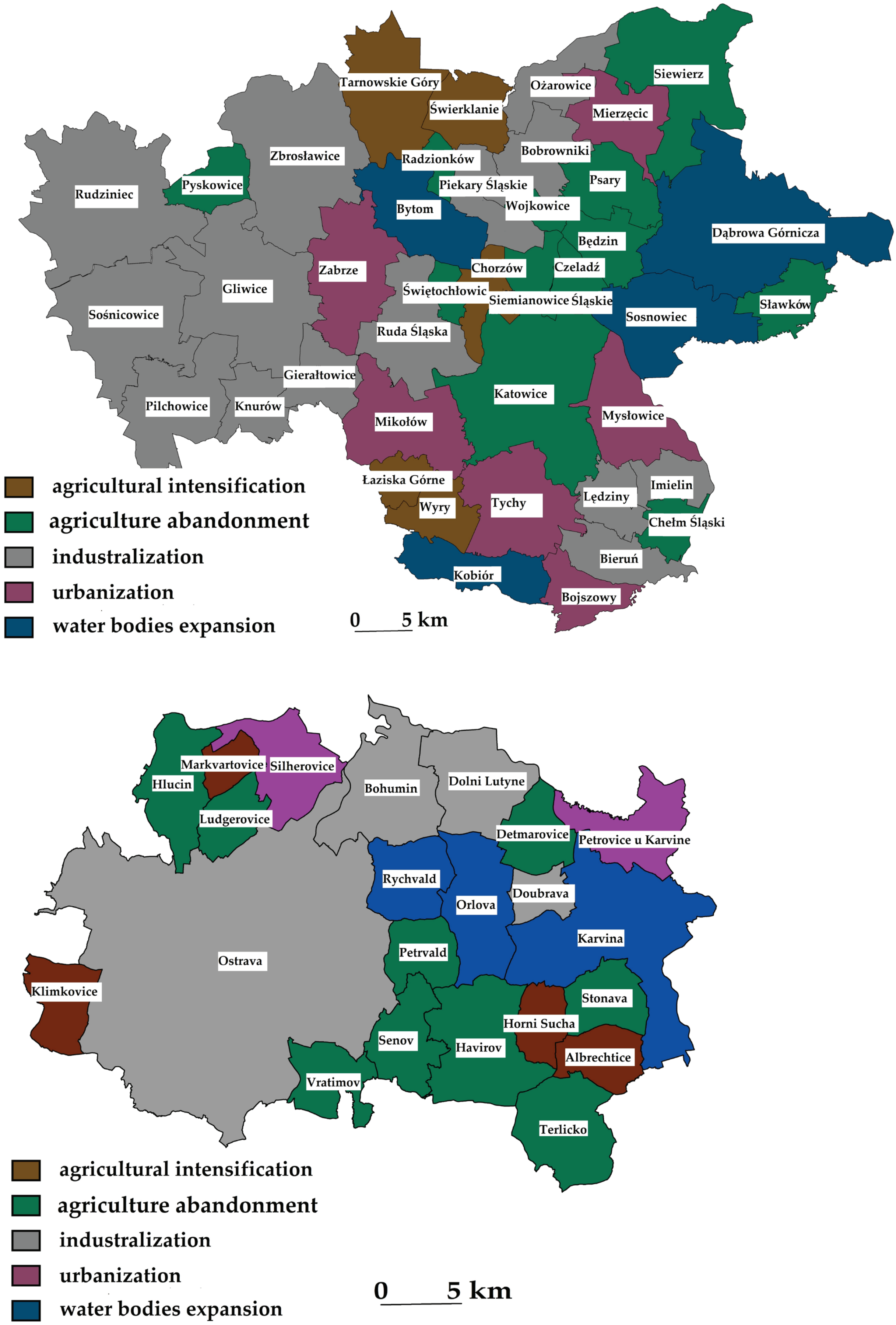

Figure 7. Main processes of landscape transformation during the 2000-2018 period in GZM (upper) and OKR (bottom).

built-up, industrial and agricultural land abandonment was most evident, along with a decrease in agricultural areas, especially orchards and plantations. The last sub-period (2012-2018) was characterized by a further increase in built-up, industrial and recreational areas with a decrease in orchards and plantations and open landscapes.

In the OKR area on the Czechian side, such dynamic processes of transformation of one type of coverage into another do not appear to have taken place throughout the period. Nevertheless, it is worth noting the growth of industrial, recreational and agricultural land abandonment. On the other hand, most agricultural land – arable fields and mixed crop land, as well as uncultivated land – declined. In the first period of 2000–2006, there was a rapid increase in industrial and agricultural land abandonment with a loss of mainly agricultural areas. The second period, 2006–2012, was characterized by an increase in built-up and recreational areas with a loss of industrial and mining areas. The most recent period, 2012–2018, saw very little change within the land cover transformation but detect an increase in industrial areas.

3.4 Processes of Landscape Transformation – General Approach

The main process changing the landscape in the study areas is suburbanisation. There was both urban sprawl into neighbouring rural areas and inner suburbanisation inside cities (Solecka et al. 2017). Suburbanisation takes place mainly in post-industrial areas and agricultural areas, as well as in wastelands inside agglomeration cities (Fig. 7). The second process responsible for landscape transformation is re-industrialisation (Pukowiec-Kurda, Vavrouchova, 2020). This is combined with the development of the transport network, the construction of high-tech industrial facilities, warehousing, logistics and transhipment centres and the agricultural lands abandonment. The last of these processes is related to the phenomenon of abandonment of agriculture in favour of other activities (Kowalewski et al., 2019). Moreover, more and more plots of land are reclassified for construction and prepared for further urban expansion. The next process is an increase in the surface water area (Fig. 7). This is related to the reclamation of post-industrial areas using water and their conversion into recreational areas (flooding of pits). Sometimes it is caused by the subsidence of underground mines and the filling of pits with water. In both the studied areas it was possible to observe the decline of mine sites and facilities, which are converted into tourist facilities, abandoned or demolished. In the GZM area, strong landscape transformation processes are visible in every municipality, but in the OKR they only appear in municipalities connected to coal mining and are weaker.

3.5 Processes of Landscape Transformation – Detailed Approach

Urbanization or more precisely suburbanization is the main process changing the landscape of the study areas. The phenomenon of suburbanization occurs internally (inside cities) as well as externally (in suburbs). In space, it manifests itself in an increase in the acreage of residential development areas. In the entire area of the GZM in the studied period 2000–2018, the acreage of land allocated for residential development increased by 15.5% of the area. In the Czechian OKR it was only 2.5%, but the phenomenon is present. In the GZM, a substantial increase in built-up areas (i.e., IRCH = between 20 and 30) was recorded in the municipalities of Bobrowniki, Bojszowy, Czeladź, Lędziny, Mikołów, Ożarowice, Rudziniec, Siewierz, Sławków, Sośnicowice, Tychy and Zabrze. Particularly noteworthy are the municipalities with the highest index, as in some of them the area of residential buildings has increased several times: Psary (IRCH=68), Mierzęcice (IRCH=60), Mysłowice (IRCH=77) and Imielin (IRCH=555). Figure number 8 presents the situation in Imielin municipality (Fig. 8). In the OKR of the Czechia, the phenomenon is much weaker, with the largest numbers in Bohumin (IRCH=11), Petrovice u Karvine (IRCH=15) and Silherovice (IRCH=6). In some municipalities, like Doubrava, for example, the opposite phenomenon is recorded, i.e., the loss of residential development.

The second process that has contributed most to the transformation of the landscape of the study areas is industrialization, but in the former industrial districts, this is now called re-industrialization. It occurs mainly on the outskirts of metropolises and cities, in the form of concentrated spaces of eco-

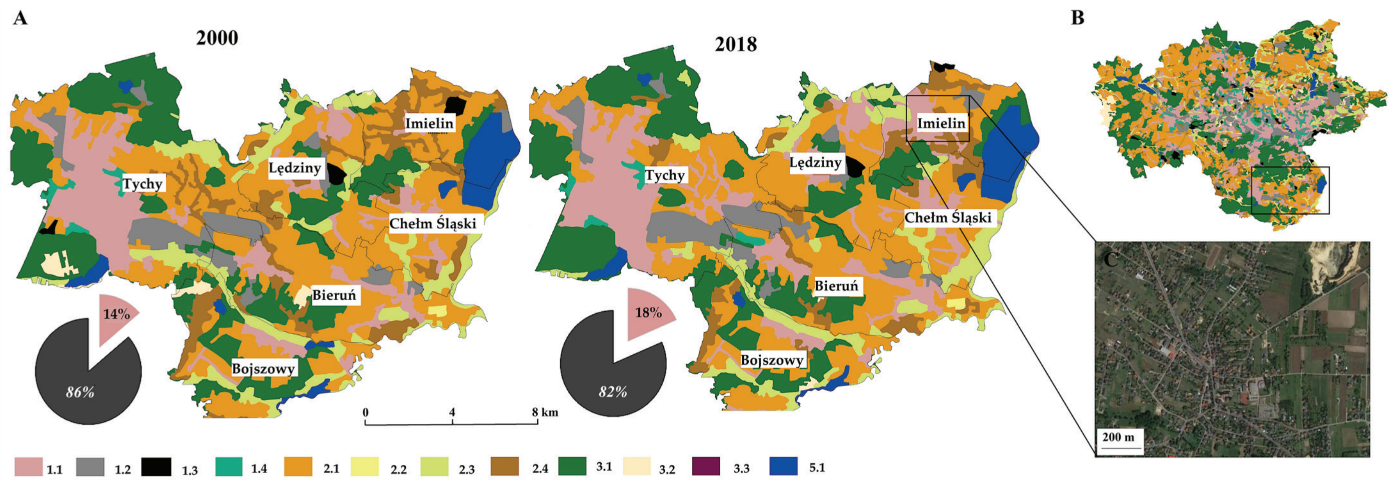

Figure 8. Case study of urbanization process in Imielin municipality in GZM. Note: The legend refers to CLC Level 2 land cover types: 1.1 Urban fabrics; 1.2 1.2 Industrial, commercial and transport units; 1.3 Mine, dump and construction sites; 1.4 Artificial, non-agricultural vegetated areas; 2.1 Arable land; 2.2 Permanent crops; 2.3 Pastures; 2.4 Heterogeneous agricultural areas; 3.1 Forests; 3.2 Scrub and/or herbaceous vegetation associations; 3.3 Open spaces with little or no vegetation; 5.1 Inland waters. The maps on the right show the location of an example of the study area within the GZM and a satellite image of the area as evidence of the processes taking place.

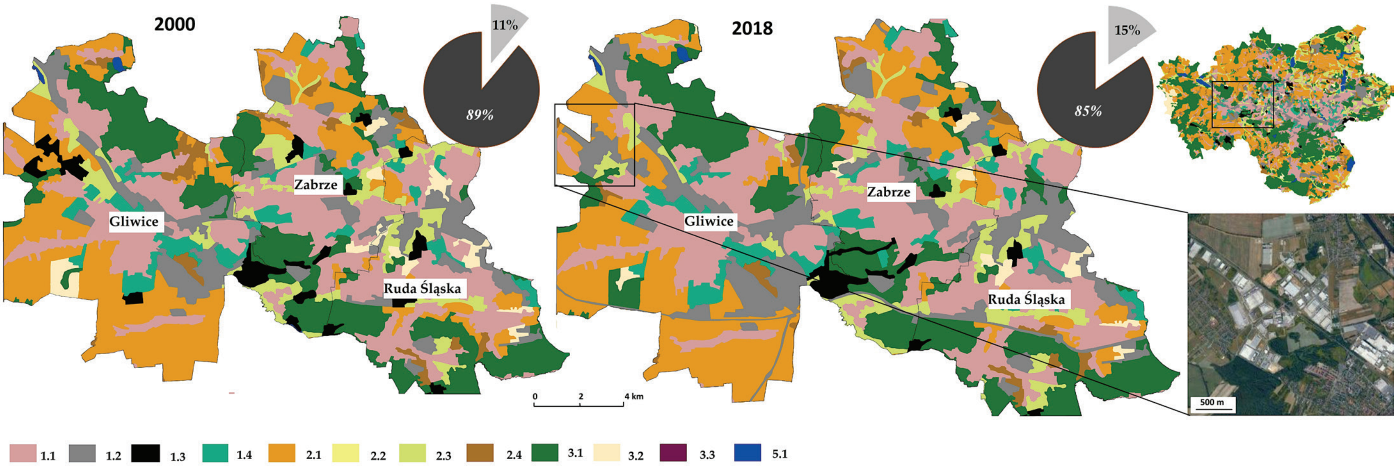

Figure 9. Case study of industrialization process in Gliwice municipality in GZM. Note: The legend refers to CLC Level 2 land cover types: 1.1 Urban fabrics; 1.2 1.2 Industrial, commercial and transport units; 1.3 Mine, dump and construction sites; 1.4 Artificial, non-agricultural vegetated areas; 2.1 Arable land; 2.2 Permanent crops; 2.3 Pastures; 2.4 Heterogeneous agricultural areas; 3.1 Forests; 3.2 Scrub and/or herbaceous vegetation associations; 3.3 Open spaces with little or no vegetation; 5.1 Inland waters. The maps on the right show the location of an example of the study area within the GZM and a satellite image of the area as evidence of the processes taking place.

nomic zones, sometimes in former post-mining areas such as in Gliwice-Łabędy (Fig.9). The highest values of the IRCH index are reached in Bobrowniki (IRCH over 16,000), Gierałtowice (IRCH=329), Imielin (IRCH=107), Ożarowice (IRCH 81.5), Pilchowice, Siewierz and Zbrosławice (IRCH=100), Rudziniec (IRCH=131) and Sośnicowice (IRCH=95.6). In the OKR in the Czechia, the phenomenon of industrialization is evident in Bohumin, Havirov (IRCH=13), Karviná (IRCH=11) and Ostrava (IRCH=10). In the entire area of the GZM, 19% of the area devoted to industry has been added in the period under review, and in the OKR 9.2%.

Among the most important processes changing the landscape, it is still worth mentioning and detailing the agricultural land abandonment. In the landscape, this usually manifests itself in the overgrowth of arable fields, the formation of wasteland and even the growth of young forests through natural succession. This phenomenon manifests itself in the landscape

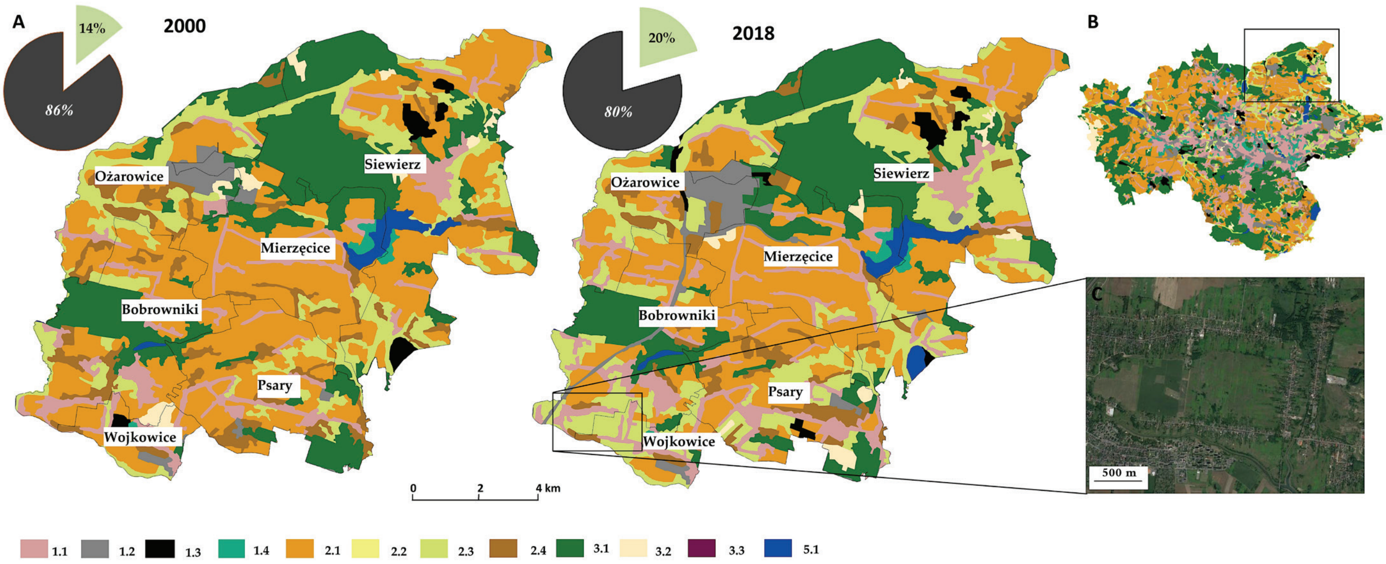

Figure 10. Case study of agriculture abandonment process in Bobrowniki municipality in GZM. Note: The legend refers to CLC Level 2 land cover types: 1.1 Urban fabrics; 1.2 1.2 Industrial, commercial and transport units; 1.3 Mine, dump and construction sites; 1.4 Artificial, non-agricultural vegetated areas; 2.1 Arable land; 2.2 Permanent crops; 2.3 Pastures; 2.4 Heterogeneous agricultural areas; 3.1 Forests; 3.2 Scrub and/or herbaceous vegetation associations; 3.3 Open spaces with little or no vegetation; 5.1 Inland waters. The maps on the right show the location of an example of the study area within the GZM and a satellite image of the area as evidence of the processes taking place.

in several indicator values, including an increase in overgrown land (class 2.3) or wastelands and a decrease in agricultural land. In the GZM, almost 20% of the area was abandoned in this way in the 18 years studied, and in the OKR 12%. During the same period, 13% of arable land and more than 90% of orchards and plantations were lost in the GZM, and 8% of arable land and 9% of orchards and plantations in the OKR. In the GZM, the acreage of agricultural land abandonment increased significantly in some municipalities: Wojkowice (IRCH=403.5), Czeladź (IRCH=307), Radzionków (IRCH=100) and Bobrowniki and Sławków (IRCH=77 and 70, respectively). Figure number 10 presents agricultural land abandonment in the Bobrowniki municipality. As for the loss of arable fields, the largest losses (IRCH less than -50) were recorded in the municipalities of Sławków, Wojkowice and Imielin and there were also substantial losses in Bobrowniki, Chorzów, Czeladź, Dąbrowa Górnicza, Psary, Siemianowice Śląskie and Siewierz (IRCH between -20 and -50). It is worth noting that all arable land disappeared in Sosnowiec during the period under review. In the case of the Czechian study area, the process is extremely dynamic. The loss of arable fields has occurred in the municipalities of Bohumin, Dolni Lutyne, Ostrava, Petrovice u Karvine and Vratimov to a medium degree (IRCH of about -10). In Terlicko and Senov it is already more intense (IRCH of -26 and -36, respectively), while in Doubrava the fields have practically disappeared. As for agricultural land abandonment, the highest IRCH values were observed in Petrovice u Karvine (IRCH=380), Stonava (IRCH=111), Havirov, Detmarovice and Vratimov (IRCH=100), as well as in Senov (IRCH=53).

4 Discussion

The transformation of Central European countries over the past 30 years, their accession to the European Union and shift away from a traditional resource economy and the associated economic development are transforming the landscape (Antrop, 2004). In addition, the modern, consumerist way of life affects not only the consumption of goods but also the use of space (Mullins et al., 1999; Jayne, 2006). The effect in the form of dynamic landscape transformations is all the more apparent. However, as it turns out, it is occurring to varying degrees and with different dynamics in the various Central European countries (Verburg et al., 2006). The Central Europe area is unique in terms of land transformation due to its post-socialist past and the systemic, economic, political and therefore spatial transformation that took place in the 1990s (Malý et al., 2020). Using the example of the areas studied, it is evident that the rate of change is significantly higher in the Polish GZM metropolis than in the Czechian OKR. The cause of these differences is that the GZM is more differentiated historically, culturally and economically than the OKR. What's more, the size of the urban centres also influence this, as the Polish metropolis has a population of more than 2.2 million, while the OKR has a population less than half that size. Humans are the causal agent of spatial change, so a larger population will be associated with greater change. Another reason is the country's spatial policy. The Spatial Development Policy of the Czechia (2021) emphasizes the need for sustainable spatial management in every aspect of space. The need to maintain and continue compact development and minimize landscape fragmentation while taking care of ecological systems is emphasized. Unfortunately, in Poland, the disclaimers on the manner of development and care for space are voluntary on the part of local authorities, and the Landscape Act (Dz. U. z 2015 r. poz. 774, 1688) does not directly affect the protection of landscape. Although the Landscape Act has provided the tools for this study, the effects of the currently conducted landscape audit will only become apparent after many years. Meanwhile, a 2018 Report by the Polish National Spatial Planning Committee PAN (KZPK PAN) on spatial chaos argues that it costs the country PLN 83.4 mld (€17.7 mld) annually (Kowalewski et al., 2018). The authors point out that the main reason is flawed local zoning plans, which allow 'semi-wild' residential settlements, where approvals for house construction are issued by the local authority (Śleszyński et al., 2020).

One of the effects of mismanagement of space is the dynamic and chaotic process of suburbanization. It is all the more harmful if its effect is urban sprawl (Cieślak et al., 2020; Solecka et al., 2017). This is unfortunately a common phenomenon in many countries (Travisi et al., 2010, Hennig et al., 2015; Gomez-Antonio et al., 2014) including Central Europe. In a special way, the phenomenon of urban sprawl is occurring in post-socialist cities (Kovács et al. 2019). It consists in rapid and usually disorderly and unorganized expansion of cities on their periphery (Wu et al., 2020). Communication and living infrastructure has to be brought to the chaotically formed settlements, sometimes far from the dense building line, which significantly increases operation costs. Urban commuting zones are expanding, commuting distances are also increasing, and this in turn translates into environmental pollution by exhaust fumes, as most of the suburban residents travel to work by car (Karanosiou et al., 2014). Above all, such activities change the landscape, which becomes compacted by the transportation network and the development of new houses (Kjaeras, 2020). The process of its fragmentation is deepening. In the post-socialist countries of Central Europe, the processes of transformation from former industrial districts to modern cities have occurred dynamically and sometimes chaotically. This includes the processes of suburbanization, which have resulted in the shrinking of cities and the growth of peripheral areas (Stryjakiewicz, 2022). This phenomenon is evident in many municipalities in Poland in the GZM study area (Wojewodzic et al., 2021; Basista, Balawejder, 2020). In some (e.g., Imielin), the acreage of residential development has increased by several hundred percent, which also has a huge impact on the quality of life in such an area. The scale of suburbanization phenomena in the GZM area is therefore enormous. Although this process is also taking place in OKR, it does not assume such a large scale. It is pointed out by P. Rumpel and O. Slach (2022), who point to suburbanization as one of the main reasons for the demographic shrinkage of Ostrava and the emergence of suburban neighbourhoods in the rural municipalities around the city. The intensity of the phenomenon in the GZM compared to the OKR may be due to the fact that the area has a much larger population, so migration movements from the city to the periphery are definitely greater.

Developing cities need to be supplied with all kinds of goods. In addition, people need places to work. These are found in emerging, new industrial zones associated with the phenomenon of re-industrialization (Krzysztofik et al. 2016). Although the two areas studied are traditionally regions associated with industry and mining, the currently emerging industrial spaces have nothing to do with tradition. Modern, often high-tech, extrusion plants are popping up along the main transportation routes (highways, express ways), as are warehouse centres and logistic and transshipment centres. Some of these facilities are built on the sites of former mining plants, closed due to the unprofitability or abandonment of the extraction of resources. This is the genesis of the economic zone in Gliwice-Łabędy. Unfortunately, in Poland, this often happens on former farmland, which is converted from agricultural plots into building plots and sold for industrial or construction purposes. According to Kowalewski et al. (2019), agricultural plots converted into building plots in Poland in 2014 accounted for 13% of land in suburban zones. While in the Czechia, large shopping centres are also being built on post-mining wastelands, on the site of former waste dumps and landfills. Unused land, e.g., post-mining areas, former dumps along the A1 motorway, are being used to locate logistics centres, shopping centres, e.g., Outlet Moravia, or municipal facilities, e.g., a garbage dump (Vojvodikova et al., 2019). Although large area companies, facilities are located on the outskirts of cities, small companies, IT industry, high-tech are still concentrated in the inner city (Ženka et al., 2021).

Very good examples of revitalization of former brownfield sites can be cited in both areas. In both areas, mining areas are disappearing, while recreational areas with tourist facilities, retail and service areas or simply new housing developments are appearing in their place. A good example is the Nova Karolina housing development in Ostrava with apartment buildings, a shopping centre and office spaces that serve residents, or Dolni Vitkowice with a steel mill turned into a tourist facility (Cynk, 2022). In Poland, Siesia City Centre, which is a multi-functional shopping and entertainment centre on the site of the Gottwald Coal Mine in Katowice (Gaidzik, Chmielewska, 2020), serves as an example of the revitalization of coal mine sites. In turn, a cultural, recreational and sports zone with exhibition halls, a museum and walking areas was created on the site of the Katowice Coal Mine (Badura, 2021).

The growing phenomenon of suburbanization and re-industrialization is developing due to the availability of land. Unfortunately, these are not areas that were designated for development with new settlements or factories and warehouses from the top down in master plans (Śleszyński et al., 2018). Rather, these facilities are being built at the expense of other land previously used for other purposes, most often agricultural. Sometimes new houses and warehouses are built on plots of land that were previously arable fields or have been fallow for several years (Kozak, Pudełko, 2021). The problem of agricultural land abandonment is a widespread phenomenon in Central and Eastern Europe that is related, among other things, to the results of the collapse of socialism and the agricultural mechanisms associated with it (Janus, Bozek, 2019). This is confirmed by numerous works on the subject from the Central and Eastern Europe (Fayet et al., 2022; Visockiene et al., 2019; Goga et al 2019). Each of these developments is detrimental to the landscape. There may be a direct conversion of agricultural land into built-up land or an agricultural land abandonment with the possibility of using the plot for development later on (Fayet et al., 2022). Sometimes the process of agricultural land abandonment has another cause, which may be a departure from agricultural traditions, the unprofitability of agriculture or a change to other work such as in services (Castillo et al., 2021). Nevertheless, in space such a process is always recorded by the overgrowth of agricultural land, where natural succession turns arable fields, orchards and pastures into wasteland (Ustaoglu, Collier, 2018). Agricultural land abandonment processes are popular in Poland, including in metropolitan areas, also in the GZM (Sroka et al., 2019; Pukowiec-Kurda, Vavrouchova, 2020). In studies of land cover types, the phenomenon will manifest itself in a loss of agricultural land and an increase in overgrown land, as can be seen around Pyrzowice and Bobrowniki in the GZM (Fig.11). The situation is similar in the OKR area of the Czechia, where this phenomenon has been occurring for many years now, but with greater intensity after the collapse of socialism (Zelinka et al., 2021). The area of arable fields in the OKR decreased by 3% during the research period. From the point of view of land use, this is an unfavourable phenomenon, and the resulting areas of residential or industrial development are chaotic and unplanned. Space is thus wasted, not to mention the loss of ecological functions from previously functioning agriculture (Lasanta et al., 2015). Also, the emergence of wasteland has a negative spatial dimension, especially aesthetically, but also in terms of planning (Śleszyński et al., 2018).

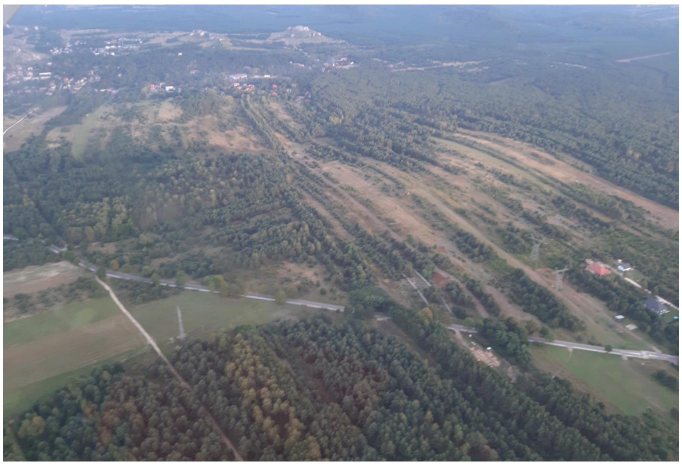


Figure 11. Abandonment in GZM in 2020 – north part of Silesian Metropoly. Author: Katarzyna Pukowiec-Kurda (September 2020).

In the literature on land cover change, land use planning and cartographic sources, the issue of tools for assessing change is strongly debated (Alphan, 2017; Bičík, Kupková, 2007; Deslatte et al., 2022). The selection of appropriate indicators and the selection of data sources are both discussed. Indicators that determine landscape transformation are widely used in the literature, for example, by R. Belda-Carrasco et al. (2019), R. Silva et al. (2020), P. Krajewski (2019), P. Krajewski, I. Solecka, and B. Mastalska-Cetera (2017), H. Vavrouchova and F. Toman (2007), G. Németh, D. Lóczy, P. Gyenizse (2021) and I. Cieślak with A. Biłozor (2022). In the studied area, implemented indicatiors have been partially examined by K. Pukowiec-Kurda and H. Vavrouchova (2020). Although landscape indicators have some limitations, such as their sensitivity and measurement inaccuracies, they are still one of the best methods of determining landscape transformation. Significant limitations in the use of indicators appear when inaccurate or defective spatial data are used (Śleszyński et al., 2020). Land cover data is most often used in landscape research, most importantly in Europe in the Corine Land Cover database. This database has its limitations, which result from the scale of the study, the frequency with which aerial photos are taken for analysis, and the accuracy and reliability of the analysis, but it still remains the most up-to-date and accessible and covers the largest area (Cieślak et al., 2020). Although many authors point to its shortcomings and others are testing its parameters and accuracy, it has many supporters who say that it is suitable for landscape studies of a regional nature.

5 Conclusions

Summarizing the research on the main directions of landscape transformations and the processes that affect them in post-industrial urban areas, the most important research findings are:

- the main processes driving the transformation of the landscape are suburbanization, reindustrialisation in the form of modern industry and the related development of transport and logistics and the agriculture land abandonment;
- these processes determine the main transformations of the area, increasing the acreage of the settlement networks and industrial and service buildings, and the compaction of the road network while reducing the acreage of agricultural land;
- both study areas are subject to landscape change, but it is much stronger in the GZM (Poland) than in the OKR (Czechia);
- three phases of landscape transformation can be distinguished in the GZM in the study period, whereas in the OKR one phase is ongoing (continuous reduction of changes);
- the processes of landscape transformation are similar in both areas, but in the GZM they appear over the whole area and with greater force while in the OKR they are weaker and only affect selected sites;
- some of the processes observed are related to the transformation of traditional mining areas into metropolises.

Conflicts of Interest

The authors report no potential conflict of interest.

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