PRESSto.

STUDIA HISTORIAE OECONOMICAE
UAM Vol. 43/1 Poznań 2025
zhg.amu.edu.pl/sho

RESOURCES AND METHODS

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USE OF SAS STUDIO SOFTWARE IN THE ANALYSIS AND VISUALISATION OF SPATIAL DATA ON HISTORICAL CHANGES IN LAND USE AND LAND COVER IN SOUTH-EAST POLAND IN THE TWENTIETH CENTURY

Abstract: The use of statistical tools is becoming increasingly useful for the analysis of spatial numerical data. The following article attempts to create a model of changes in land use and land cover in the years 1900 and 1990 using SAS Studio software. The created model referred to the area of historical West and Central Galicia (part of East Galicia). This is the area of the former Austrian partition, and it is currently located within the borders of Poland. The evolution of the share of agricultural and forest areas in the system of statistical localities in the analysed years was subjected to analysis. The index of change in land use and land cover structure was calculated based on share differences. The biggest changes in land cover were recorded in the eastern part of the region under study and in areas where political borders were modified. A model of change in the structure of land use and land cover was created based on selected indices of the level of economic development at the beginning of the twentieth century. A comparison of the model created with the values observed on the basis of statistical data revealed that the greatest disturbance of the model took place in the eastern part of the region under study. This was mainly due to the political and demographic changes that took place in the twentieth century.

Keywords: spatial analysis, Galicia, landscape, statistical methods, land cover, land use, SAS Studio

https://doi.org/10.14746/sho.2025.43.1.008

INTRODUCTION

The previous century was a period of highly dynamic civilisational and technical progress, as well as intense sociopolitical changes occurring both in Poland, throughout Europe and worldwide. The development of Polish industry and urbanisation of the country in the twentieth century caused, among others, significant changes in land use (Popławski, 2009; Dorocki et al., 2019). Changes in land cover are considered to be one of the main indicators of global socioeconomic changes. The model of change in land use and the accompanying changes in land cover therefore illustrate the long-term basic factors of regional development, such as economic development, demographic changes and urbanisation (Munteanu et al., 2014).

New economic and political conditions that were introduced in Poland after 1945 and the progressive processes of globalisation that took place at the end of the twentieth century and at the beginning of the twenty-first century. Wantuch-Matla et al. (2023) led to significant changes in the structure of use and development of the country (Harańczyk, 2015). Changes in land use are mainly a function of economic development and agricultural policy (Lambin et al., 2001; Pongratz et al., 2008; Lambin and Meyfroidt, 2010). However, an important factor affecting land use is also the change in the needs and style of consumption, as a manifestation of increasing wealth of the society and its entrepreneurial attitudes (Peña et al., 2007; Matyka 2012). It appears that cultural factors significantly affect the direction in which social and economic changes progress (Dorocki and Struś, 2017; Dorocki, 2022), which in turn affects land use (Wrbka et al., 2004; Bürgi et al., 2017). These changes are especially visible over longer periods of time (Bičík et al., 2001; Hurtt et al., 2006).

In spatial terms, changes in land use were particularly visible in mountain regions, including the Polish Carpathians, where land use transformations forced by socioeconomic and political changes that took place after 1918 and 1945 (Affek et al., 2021; 2023; Bucała-Hrabia et al., 2022). Particular importance should be attributed to population migration (including the depopulation processes of the Beskids area) and the change in the national and ethnic composition of southern Poland following World War II (Bucała-Hrabia, 2017; Munteanu et al., 2014; Kanianska et al., 2014).

The most evident changes in land use and land cover were recorded at the end of the twentieth century in mountain and submontane areas,

where changes became more intensive during the economic transformation of the country after 1989 (Górz, 2003) and are manifested by a significant reduction in the share of arable land in favour of forest areas (Bański, 2003; Zabierowski, 1995; Kozak, 2005: 20–26). On the other hand, the twenty-first century is a time of a gradual increase in built-up areas, which is related to the investment pressure of developers in areas bordering large and medium-sized cities and regions which are attractive in terms of tourism and nature values.

THE AIM OF THE ARTICLE

The main aim of the article is to present the possibility of applying statistical methods belonging to the class of spatial regression models (Bednarowska, 2015; Lang et al., 2019) to the analysis of historical geographical data. The changes in the landscape that took place over a century in the area of the Polish lands belonging to the former Austrian partition (West and Central Galicia) were chosen as an example of the application of the method. It is also a presentation of an alternative way for presenting spatial statistical data.

The following study attempts to answer the question: are the changes in the structure of land use and land cover in south-east Poland related to the historical economic conditions from the beginning of the twentieth century? Data analysis was carried out employing the SAS Studio statistical software and using the MIXED procedure.

Historical statistical data from 1900 depicting land use were taken from the 12th volume of *the Gemeindelexikon der im Reichsrate Vertretenen Königreicheund Länder* (). These data sets were assigned to the location of modern statistical localities (SIMC – downloaded from the CSO resource). Each SIMC locality was assigned land cover according to data from the Corine Land Cover (CLC) program. For the GIS analysis, data sets from 1990 were used, which are originally available in the shp. format on the Copernicus website. Therefore, in the course of analysis, the historical share of land use of the cadastral community [Kastralgemeinden] (Ostafin et al., 2023) from 1900 and land cover (CLC) for the year 1990 were compared. Despite the fact that these data sets are not identical, numerous studies tend to compile them (Ciołkosz and Poławski, 2005; Ciesielski

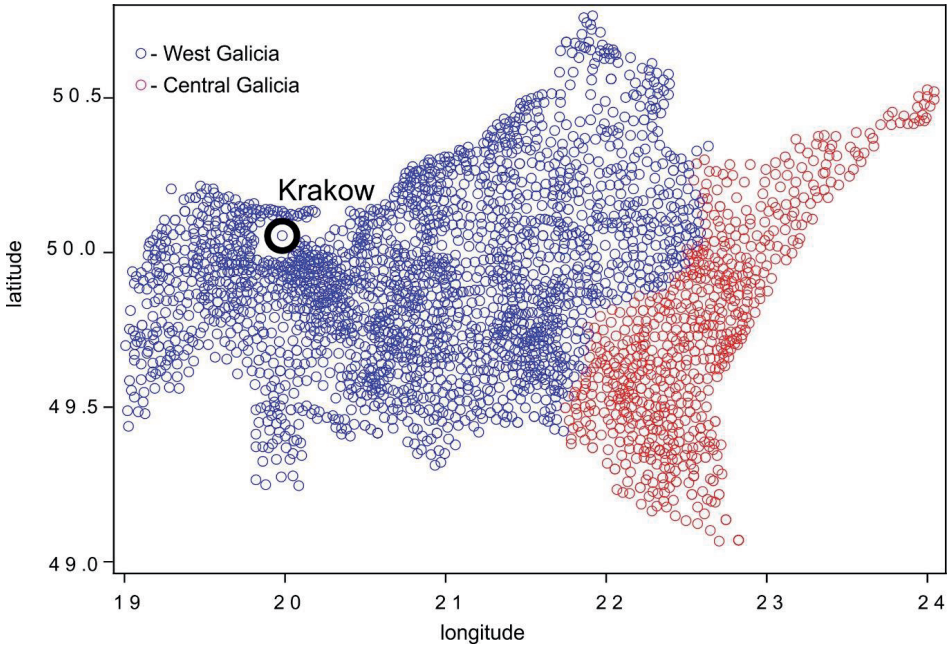
and Będkowski, 2014; Dorocki et al., 2019; Żychowski and Jucha, 2020), as it should be assumed that changes in land use affect changes of land cover. For this reason, only the term "land cover" will be used in the further part of the work as the designation of the indices calculated on the basis of both variables.

It should be noted that the official statistical data contained in the Austrian records is characterized by a significant discrepancy with regard to the actual state, including outdated data, which is demonstrated, for example, by the statistical data published in 'Szematyzmy Królestwa Galicji' (Kramarz, 2007) and information included in the studies of Tadeusz Pilat, among others 'Rocznik Statystyki Galicyi' or 'Podręcznik statystyki Galicyi' (Franaszek, 2000).

While comparing the location of historical localities and their contemporary counterparts, official spatial data from the resources of the Head Office of Geodesy and Cartography were used: the National Register of Boundaries (PRG) and the National Register of Geographical Names (PRNG, points with geographic coordinates of localities). The map for Galicia period was drawn on the basis of the maps of the Military Geographical Institute at a scale of 1:100,000 and other cartographic publications of the Austro-Hungarian administration.

A total of 2,638 villages, 102 parts of villages, 62 settlements, parts of settlements and colonies of villages, 109 cities and 226 parts of cities were analysed (historical output data). Individual historical towns included in the 1900 census record were located separately in accordance with cartographic studies of the contemporary administrative division as per statistical localities. In the case of a clear inconsistency between contemporary and historical boundaries, historical or contemporary units (less frequently) were merged in order to obtain units whose boundaries would be as consistent as possible in the analysed time period. In such cases, the statistical data for the merged units was recalculated. After verifying the location of localities and their aggregation as per modern administrative units, 2,951 towns remained, as Krakow itself incorporated 71 historical units within its borders (Figure 1). In the further analysis, inference was conducted on the basis of the obtained set of localities defined as the geographic coordinates of a polygon centre. Presenting localities as points in the system of geographical coordinates is an example of a typological representation of space (Longley et al., 2008: 90–111). This practice is an alternative method of analysing spatial phenomena for statistical data.

Figure 1: Distribution of the analysed localities in the system of geographic coordinates divided into historical administrative units



Source: The author's own elaboration based on statistical data.

METHODS

The article applies cliometrics (Greasley and Oxley, 2010), which is an approach in which the parameterized model allows for calculating the expected values based on various scenarios (in this case, modification of locality parameters) and comparing them with the values observed. Therefore, on this basis the answer to the following question can be provided: "What would the hypothetical development of a locality have been like if the parameter of this locality were different?" Expected values may also be obtained from the resulting model for various values of locality parameters.

Since the model is created on the basis of data sets for two time periods (initial and final), time-jump analysis was applied (Statuto et al., 2020) which consists in comparing two data sets which are distant in time. As the result, it is possible to distinguish in which cases the greatest changes occurred in the analysed research aspect. It is only at this stage that it

is feasible to apply the evolutionary approach (Myga-Piątek, 2005) in the aspect of retrospection, i.e. finding the causes contributing to the deviation from the adopted model of landscape changes in the region under study (Myga-Piątek, 2012: 63–75). Similar research has already been conducted with regard to numerous regions of Poland. However, such a large area has rarely been investigated and the studies were mostly based on remote sensing methods (Trzepacz, 1988; Kozak, 2005: 41–66; Dec et al., 2009; Kaim, 2009; Wróbel, 2021).

Time-jump analysis indirectly draws on the theory of longue durée (Braudel, 1958) which takes into account an extensive background of social and economic changes while analysing landscape diversity. This theory assumes that the model of a region's spatial structure exists in reference to the inertia of the spatial structure (Dorocki and Struś, 2017), i.e. the existence of the spatial structure of a given area fixed in time with regard to the cultural landscape. In Polish literature one can talk about the evolution of structure (Dobrowolska, 1962, 1964), in which historical process of changes are subjected to analysis in the structure of geographical space. As Z. Zioło (2011) notes, all regional shifts occur in an environment of global processes, which should be taken into account in the analysis of changes taking place locally. Among the stimuli impacting the direction and strength of changes in the region, increasing significance is ascribed to institutional factors – the neo-institutional approach (Moncayo Jiménez, 2003; Bastidas-Morales, 2015). Among the factors analysed, the influence of non-economic factors is often emphasized (Gałązka, 2017). They refer to formal and informal norms of social life, rules of behaviour and customs which coordinate the behaviour of the region's population (Grosse, 2002). The term social capital is frequently used with reference to regional development (Zioło and Rachwał, 2019).

The land cover change index (OR_{AxB}) calculated on the basis of the odds ratio and the logit function [1] was employed in the analysis (Dorocki et al., 2019). Subsequently, the change in the land cover structure was calculated for the years: 1900 (A) and 1990 (B) [2].

$$logit(p) = log\left(\frac{p}{1-p}\right) \quad [1]$$

$$OR_{AxB} = \frac{S(A)}{S(B)} = \frac{\frac{P(A)}{1-P(A)}}{\frac{P(B)}{1-P(B)}} \quad [2]$$

where:

p – probability of success (occurrence of a given event),
OR_{AxB} – land cover change index,
P – proportion of a given type of land cover/land use,
A – data for the year 1900 (land use),
B – data for the year 1990 (land cover),
$P(A)$ – share of area in 1900
$P(B)$ – share of area in 1990
$S(A)$ – odds ratio for 1900
$S(B)$ – odds ratio for 1990

In order to avoid division by `0` the minimum value of the trait divided in half was substituted in the absence of a share of the trait in question. From the logit values obtained, an absolute value was calculated and then summed to obtain an index of land cover structure change.

The analysis was based on three types of land cover. These were: agricultural land, forest and other ones. This is due to the possibility of comparing only these data sets in two analysed time intervals (1900 and 1990) without making an assignment error while being aware of their generality. Moreover, the analysis of only three variables allows for a clearer presentation of the analytical method employed. In view of the types of land cover/land use accepted for analysis, cities and towns (classified as other types) were almost completely omitted in the study as agricultural land and forest did not usually occur within towns or cities (or they did in a very small proportion).

The relative coverage of land with a given type of its use is a value between 0 and 1 (for proportions) or 0 and 100 (for percentages), so it operates on a scale with a lower and upper limit. Difficulty arises from determining differences (whether for repeated measurements or for independent groups) both for a single type of land use (e.g. forests, not forests) and for determining a change based on all types of land use at the same time. Scales with no limits of maximum and minimum values, are not encumbered by such difficulties. The theoretical justification for using the above index is that it extends a limited scale of 0–1 and allows for operating on a range from minus to plus infinity, i.e. it transforms scales with limitations to a scale without limitations (similarly to logistic regression). The practice of applying such an approach indicates that a distribution approximating the normal one is often obtained (which further expands the possibilities of analysis). This approach allowed for obtaining results consistent with intuition.

In the further analysis of the construction of the land cover structure change model, the MIXED procedure of the SAS Studio software was used, which adjusts various mixed linear models to the data and allows the use of these matched models for statistical inference (Thiébaut et al., 2002; Stroup et al., 2018: 8–47). The mixed linear model is a generalization of the standard linear model, wherein the generalization consists in the fact that the data may show correlation and inconsistent variability. The mixed linear model therefore ensures flexibility in modelling not only average data (as in the standard linear model), but also their variance and covariance.

This study uses the regionalization of Poland developed by J. Kondracki (Kondracki and Richling, 1994) despite the fact that a newer and more accurate division from 2018 proposed by J. Solon et al. (2018) is also currently applied. However, the following study refers to the historical period, and the analysis presented is largely of an illustrative nature. Therefore, it was decided to use the division developed by J. Kondracki, which allowed for reference to earlier studies.

The analysis employed the data contained in the *Gemeindelexikon der im Reichsrate Vertretenen Königreicheund Länder*, realizing that both in the archives in Vienna and in Lviv there is accurate documentation representing data, e.g. of the Ministry of Agriculture of the Central Committee and the Galician Governorate – illustrating the statistics of changes in forestry, the layout of agricultural land, taxable lands, etc. (K.K. Statistische Zentralkommission, 1907). However, the following study is mainly aimed at presenting an advanced method of statistical analysis, which is why it was limited to the analysis of data from one statistical source. At the same time, while using time-jump analysis in the study, no reference was made to important historical events that had an impact on social and economic changes in the region under study. It was, among others, the Josephine colonization in Galicia and numerous rural colonies created in the 1880s which strongly influenced the economic development of Galicia (Lepucki, 1938: 140–152). Neither did the analysis refer to the consequences of implementing the 1852 general forestry regulation and the spatial development policy of Galicia, including the Austrian forestry policy (Nyrek, 1997).

Due to the methodological nature of the study, the text omits a review of literature relating to the issue of Galicia's historical economic development and its spatial diversity. However, it should be noted that this topic was already addressed many times both in historical times (e.g. Bujak, 1906: 53–111, 1917: 40–58), as well as in modern times (e.g. Ślusarczyk,

1999; Ślusarek, 2002: 117–166; Kargol, 2010; 2011; Karolczak, 2016; Kargol and Ślusarek, 2017). Nevertheless, the presented statistical method has never been used in this type of research. The method presented is therefore the starting point for further detailed historical research with the use of historical statistical data.

RESULTS

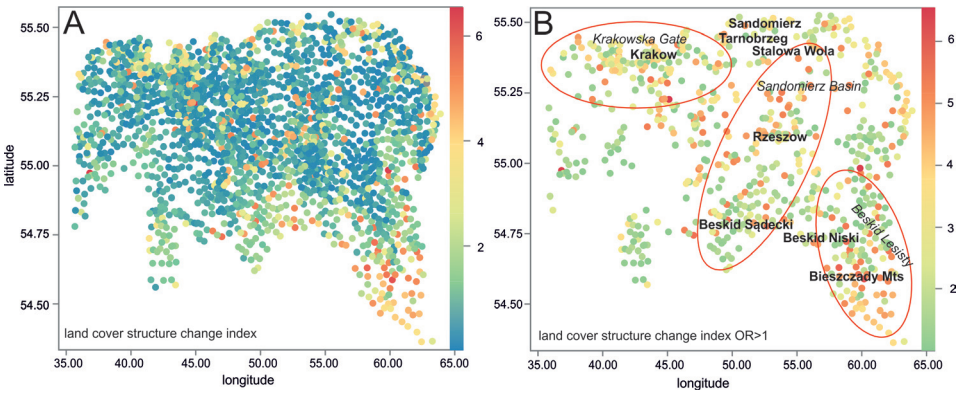
Analysing the value of the land cover structure change index, it amounted to an average of 1.24 (with a minimum value of 0.005 and a maximum value of 6.55). It amounted to 1.07 for West Galicia and 1.90 for East Galicia, respectively. It should be noted that only part of East Galicia's area was examined, i.e. the one which is currently located within the borders of Poland. Therefore, it is a region historically included in Central Galicia, which stretched between the rivers Wisłok and San (Dudzieńska, 2006), although its area was also placed between the cities of Rzeszów and Sambor (Ostanek, 2017). It should be noted that the term Central Galicia is an informal name. However, it is commonly used in the literature on the subject (Bardach, 1969; Sokół, 1989; Półćwiartek, 1999; Filozof, 2005; Stopa, 2008; Kapralski and Borawska, 2013; Salmon, 2016; Popek, 2020; Ślęczka, 2022; Buchen, 2024). In the further part of the article, this term will refer to the western areas of East Galicia, currently belonging to Poland.

Therefore, major changes in land cover occurred in the east of the area under study, which resulted from the region's history and was related to changes in national borders after 1945 as well as migration processes taking place in its area (Action Vistula – forced resettlements; Żychowski and Jucha, 2020). This is particularly evident in the median value of the analysed change index, which was almost three times higher in the case of Central Galicia (1.4) than in the case of West Galicia (0.5). Due to the smaller area of Central Galicia and its lower physiogeographic diversity, the land cover structure change index was 84.2%, while in West Galicia it reached 121.2%.

Referring to the spatial variation in the value of the land cover change index in the years 1900 and 1990, it can be observed that the smallest changes occurred in the centre of the area under study, and the largest ones along its northern and eastern borders (Figure 2A). It was these regions

that changed their geopolitical position in the twentieth century (Wendt, 1997). This mainly affected the change in the transportation system and the development of border areas.

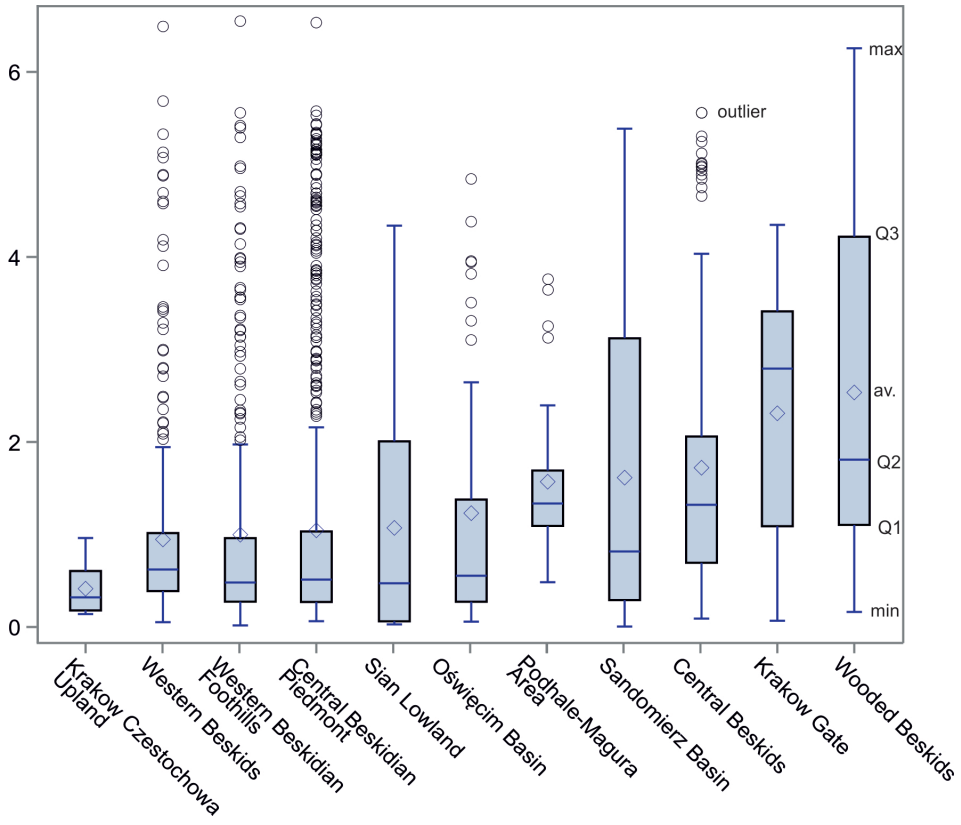
Figure 2: Values of the land cover structure change index for the years: 1900 and 1990



Source: The author's own elaboration based on statistical data.

Particularly large changes in land cover took place in the Bieszczady Mountains, around Krakow and in the region stretching from Sandomierz in the north to the Beskid Sądecki in the south (Figure 2B) – i.e. the border area between West and Central Galicia. This fact is confirmed by the diversity and average values of the land cover structure change index for the years 1900 and 1990 in the system of geographical macroregions (Figure 3). The largest average changes in the land cover structure occurred in the south-east of the region in the Wooded Beskids and in the Krakow Gate. In the first case, it is the result of displacing the population from the Bieszczady and Low Beskids areas after World War II and changes in the economic utilisation of these mountain areas (Soja, 2001; 2021ab; Bucała and Starkel, 2012). In the case of the Krakow Gate, the high average value of the change index was influenced by the urbanization process, including the development of the Cracovian agglomeration (Kowalski, 1996; Luchter, 2010: 172–195). In the case of the Sandomierz Basin, the change in the land cover structure was influenced by the process of industrialization and the post-1945 shift from the agricultural economy, as well as the development of industrial centres such as Tarnobrzeg, Stalowa Wola, or Rzeszów (Rachwał, 2002; Jucha, 2016: 23–29; Skulimowska, 2018).

Figure 3: Average and positional values of the land cover structure change index for the years 1900 and 1990 in the regional system



Source: The author's own elaboration based on statistical data.

In the next step, an attempt was made to answer the question: what historical socio-economic factors had an impact on the level of land cover changes during the studied century (which were its best match in the model of changes). Due to the lack of accurate historical data from the year 1900 showing the level of economic development, the so-called substitution data was used in the analysis conducted (Dorocki et al., 2019). Therefore, the following indices of the level of economic development were adopted for the analysis: population density, which, due to high overpopulation in the rural areas of Galicia, indicates mainly the distribution of population. Therefore, the correlation with the land cover change index is not statistically significant (Table 1). In turn, the high feminisation rate could testify to the low level of economic devel-

opment in rural areas, because at the beginning of the twentieth century women were only entering the economic life along with the process of industrialization (Żyromski, 2000) and development of the services sector (Kozak, 2014; 2019). In addition, in the east of Galicia at the beginning of the twentieth century, male supremacy attitudes were still very influential and excluded women from economic activity (Tomczyk, 2012; Czerczowycz, 2014). Despite this, the degree of feminization was higher in cities than in rural areas, which was related to the development of domestic workers. This was due to the fact that the professional activity of women in cities had already increased significantly in the nineteenth century. This process was particularly noticeable among Jewish women (Zyblikiewicz, 2015). In the case of correlation between the feminization rate and the land change index, this value is statistically insignificant, which may result from the fact that the study distinguished mainly changes occurring in rural areas, which stems from the adopted criteria of variables.

Table 1: Selected output variables – independent (historical) determining the level of socio-economic development of the area under study

year 1900	population density	femin. rate	number of people per house	number of horses per 100 people	Share of Jews	German share
Pearson correlation coefficients	0.021	0.019	0.132	0.129	0.143	0.042
true > $\|r\|$ at H0: $r_{HO} = 0$	0.3428	0.4021	<.0001	<.0001	<.0001	0.0645

Source: The author's own elaboration based on statistical data; r – correlation, r_{HO} – Spearman's rank correlation coefficient.

Another adopted index of the local level of economic development at the beginning of the twentieth century was the number of people per house. It indicates multi-storey construction and indirectly the local level of urbanization, which, in turn, is related to the degree of economic development. Another variable is the number of horses per the number of inhabitants. It testifies not only to the wealth of the society, but also to the degree of economic development, because horses were used for transport and often also as a driving force of machines. In both cases, the indices show a rate-related change in the structure of land cover at the statistical significance level of 0.0001.

Another adopted index determining the degree of economic development of Galicia at the beginning of the twentieth century is the share of the Jewish and German-speaking population. In Galicia, both the Jewish and German-speaking population provided a strong impulse creating economic development (Soja and Zborowski, 2011; Röskau-Rydel, 2011: 81–94; Broński 2014; Dolecka and Duda, 2014; Meus, 2014; Moskalets, 2019; Dorocki, 2022). While the share of the German-speaking population was clearly dominant, relative to the Jewish population, in large cities (which resulted not only from administrative functions and the influx of German-speaking officials, but also from the fact that these centres attracted entrepreneurs and scientists), the share of the Jewish population dominated in smaller peripheral centres, where it played a dominant role in creating economic development (Lehmann, 2001: 62–86). This thesis is confirmed by the statistically significant relationship between the proportion of the Jewish population and the observed changes in the structure of land cover. In the case of the German-speaking population, which largely formed the social elite of Galicia and concentrated in large urban centres, this relationship was no longer so strong. It is also important to note the German settlements (also referred to as colonies) which were located in rural areas throughout Galicia, both in the western and eastern parts. However, referring to the results of the statistical data analysis, the German-speaking population did not exert as much influence on the changes in land cover observed in the 20th century, which was related to the rural nature of the colonized regions.

The presented relationships did not take geographical location into account, therefore the MIXED procedure of the SAS Studio program was used, which allows for summarising both numerical and qualitative data and taking into account the location of the units under study in relation to each other. Typological indices were added to the previously analysed indices of the level of Galicia's economic development in fin de siècle, i.e. the division into West and Central Galicia, geographical macro-region and type of locality (city/village in 1900) (Table 2).

Table 2: Selected output variables – independent (historical) determining the level of socio-economic development of the area under study

Variables for 1900	F value	Pr. > F
West / East Galicia	27.42	<.0001
number of horses per 100 people	18.94	<.0001
share of Jews	18.49	<.0001
geographical macro-region	11.15	<.0001
number of people per house	10.45	0.0012
feminisation rate	5.62	0.0178
type (city – village)	1.31	0.2524
German language share	0.42	0.5156
population density in 1900	0.11	0.744

Source: The author's own elaboration based on statistical data. *F* – statistical test compares variances, Pr. – statistical probability.

Among the adopted indices, the West or Central Galicia was the most significant for the changes in the structure of land cover, which indirectly refers to the cultural conditions of the population living in those regions at the time, related to, among others, religion, nationality, level of education and entrepreneurial attitudes of the population (Dorocki, 2022).

Other indices related to the degree of land cover changes were the number of horses per the number of inhabitants and the share of the Jewish population. Both of these indices indirectly testify to the level of economic development of a given area.

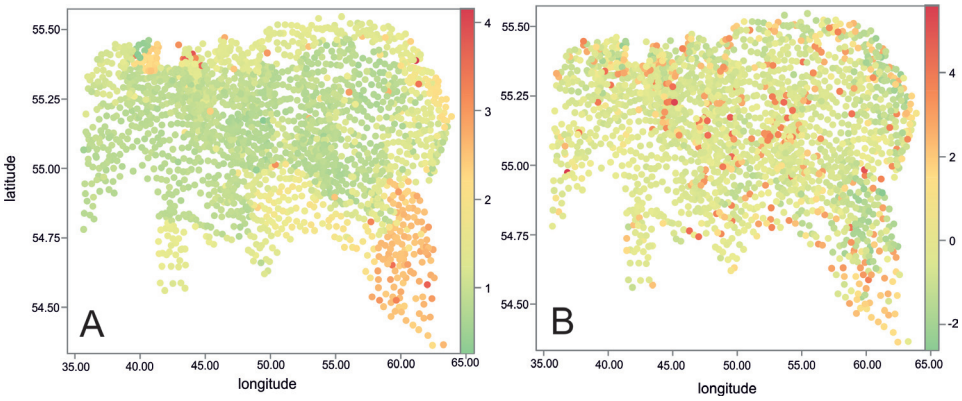
The type of geographical macro-region also shows a relationship with the level of land cover changes in the 20th century. This stems indirectly from the location in relation to administrative divisions, as well as changes in the distribution of the population in the Carpathians following World War II.

The level of urbanization presented by the number of people per building is less important, which also confirms the low importance of the type of locality (city/village) for subsequent changes in land cover.

The density of population at the beginning of the 20th century was of the least importance to the changes in the Galician landscape, which is evidenced by the significant overpopulation of the Galician rural areas (Soja, 2008: 104–107; Franaszek, 2016; Zych and Zych, 2021).

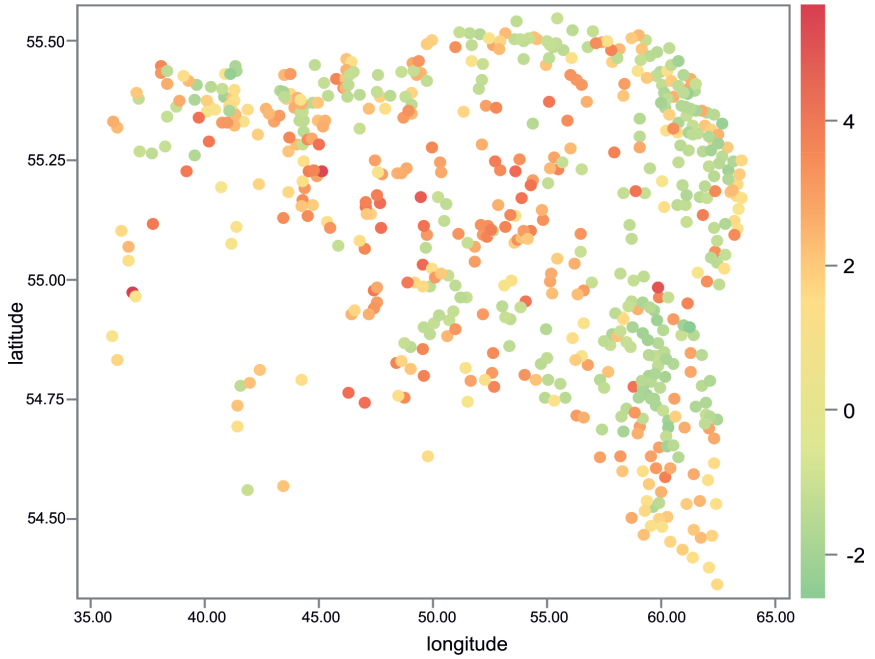
A land cover change model was then created for the years 1900 and 1990 (Figure 4A). According to the model taking into account selected output data, the largest changes in the structure of land cover took place in the Bieszczady and Beskids Foothills, in the area west of Krakow, in the Beskid Niski and Beskid Sądecki and their foothills, as well as in the Podhale region. Changes also occurred in border regions, both the historical ones in the north in the Vistula valley and the contemporary ones in the east of the region. The smallest changes in land cover were found in the agricultural areas of central Galicia. This is particularly evident in the values displaying the largest difference, i.e. above 2 and below -2 real values in relation to the model (Figure 5).

Figure 4: A model of the values of the land cover change index for the years 1900 and 1990 (A) and the difference between the values of the land cover change index for the years 1900 and 1990 and the model (B)



Source: The author's own elaboration based on statistical data.

Figure 5: Differences in the values of the land cover change index for the years 1900 and 1990 in relation to the model (-2<or 2>)

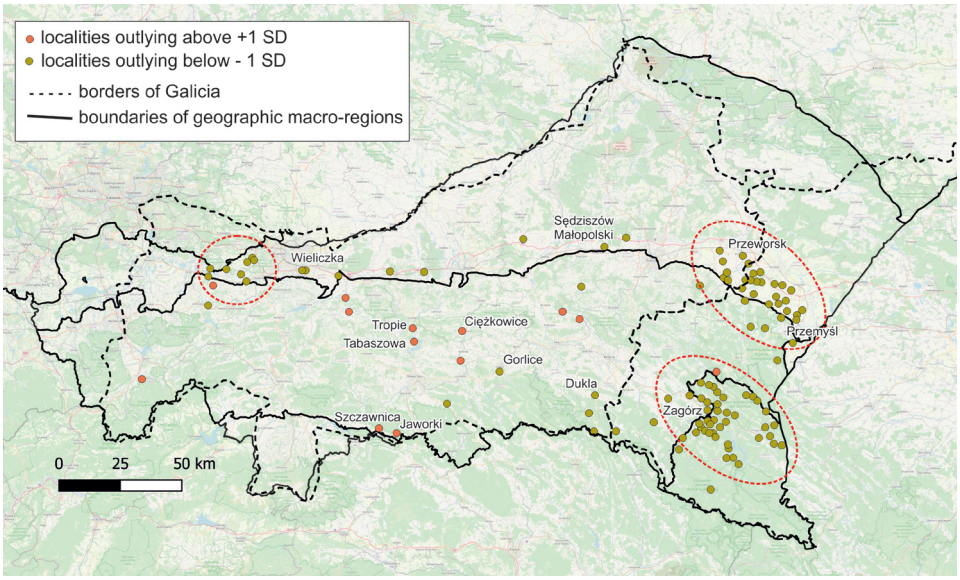


Source: The author's own elaboration based on statistical data.

In addition, the standard deviation value for the difference in the land cover change index for the years 1900 and 1990 in relation to the model was used in order to depict landscape changes. The above values are presented with regard to the course of historical boundaries and the boundaries of geographical subprovinces (Figure 6).

In relation to the model, the greatest differences in the observed level of change in land cover structure occurred in the east of the area under study. These are differences that were indicative of a lesser change in land cover structure than would result from the initial socio-economic development of a locality. These changes do not apply to mountain areas, but to agricultural regions of the foothills. It can be presumed that this was the result of a change in the geopolitical system and the demarcation of Poland's new border in the east, as well as changes in the communication network, in terms of east-west transport. At the same time, it is possible to speak of the preservation of relict borders in the differences between land cover changes in the region of former historical borders (Więckowski, 2023).

Figure 6: Differences in land cover change index values for the years 1900 and 1990 in relation to the mode 1 +/- 1 standard deviation SD (min/max)



Source: The author's own elaboration based on statistical data.

Another important factor is the human aspect. Demographic changes related to warfare during both the First and Second World Wars not only contributed to this area's depopulation, but also changed its structure. In the post-war period, there was a decrease in the share of the Ukrainian (Ruthenian) population associated with the Operation "Vistula" (Soja, 2001ab; Barwiński, 2006; Jakubowski, 2017). The second important event for the economic development of this region was the Holocaust and the post-war emigration process of the Jewish population related to both the process of Zionism development (Eisler, 2002; Berendt, 2005) and Polish post-war anti-Semitism (Semczyszyn, 2022). It is important to remember that the Jewish population was not only the dominant national group in small cities (e.g. Lesko or Sanok), but it was also the main driving force of the local economy (Potaczek, 2017: 17–21). At the beginning of the twentieth century, this area was also to a large degree inhabited by the German-speaking population (Mucha, 1992; Skulimowska, 2021) which emigrated as a result of World War II. Therefore, it seems that it was the political, economic and demographic changes occurring in Poland after 1945 that led to inhibiting the economic development of this area.

In the case of the Krakow region, the observed changes in land cover are also smaller than would appear from the potential of the city at the beginning of the twentieth century and the adopted model of land cover changes. This is indirectly related to the presence of protected areas in this region on account of natural values, which are adjacent to the city.

Other types of centres with a smaller change in the land cover structure than assumed in the model are the surrounding areas, e.g. Gorlice and Dukla, which lost their importance in comparison to the initial period of research. Similarly, localities located on the transportation route between Krakow and Rzeszów recorded smaller changes than their initial potential would indicate. It should be noted that the process of reducing the potential of small towns concerns many urban centres of southern Poland (Kwiatek-Sołtys, 2004: 19–22; Kantor-Pietraga, 2014: 202–207).

However, greater changes in the structure of land cover than the model shows occurred in mountain tourist resorts, which was common with the development of winter tourism and egalitarian spa and leisure services (Dec et al., 2009). Another factor affecting considerable changes in the landscape in the twentieth century can be found in engineering investments, e.g. ones related to artificial water reservoirs – in this case, e.g. Lake Rożnowskie.

Also, many individual factors may affect individual deviations from the adopted model of land cover changes. It can be assumed that these differences were observed more frequently in the east than in the west of the region under study, which in turn is also related to historical conditions.

CONCLUSIONS

Summarising the analyses carried out, it can firstly be concluded that the statistical methods which were employed meet the research expectations in a satisfactory manner. Thanks to them, it can be concluded that the changes in the structure of land cover in south-east Poland are aligned with the historical conditions from the beginning of the twentieth century. This testifies to a high inertia in the development of the area under study. Recognizing that the level of economic development in the year 1900 and the geographical conditions represented by macro-regions contribute to subsequent changes in the land cover structure, we managed to create a model that largely coincided with the observed changes. The his-

torical level of economic development should be distinguished among the factors which influenced the magnitude of changes the most strongly. It was very closely related to the share of the Jewish population, which was an important catalyst for local economic development. Therefore, historical events that took place in the twentieth century and influenced both the change in the national structure of south-east Poland and economic conditions (nationalization of the economy after World War II), disrupted the created model of land cover change.

Another factor affecting the deviation of the created model of changes in the land cover structure was the transformation of state borders and the associated transformation of the settlement network hierarchy. In the second half of the twentieth century, there was a clear process of the peripheralization of urban centres that were located in border regions. At the same time, the development of new industrial centres in the twentieth century did not significantly affect the changes in the land cover structure, which could also be related to the fact that it was not possible to trace the changes in land cover in towns or cities. However, the case of the Krakow area is interesting, as its changes were much smaller than it would appear from the adopted model. This may be due to the agricultural nature of this area, which only at the end of the twentieth century witnessed the impact of the process of suburbanization and investment pressure of developers, as well as a large share of areas in this region enjoying protection due to their special nature values.

Only a few selected variables were taken into account in the analysis, which resulted from their limited availability. Therefore, in order to be able to create a model of land cover changes in a more accurate way, it would be necessary to take into account a larger number of variables – referring to both the type of coverage and the output data describing the level of socio-economic development. At the same time, it should be emphasized that when analysing contemporary spatial changes with regard to geographical characteristics, it seems necessary to always refer to historical conditions.

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