



THE HISTORICAL DIVERSITY OF POLAND'S URBAN NETWORK: CLUSTER ANALYSIS VERSUS HISTORICAL REGIONS

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Abstract

The article presents an analysis of the urban network in Poland in 2010 based on the statistical method of hierarchical clustering with the aim of identifying historical regional networks of settlements. Mathematically derived clusters were compared with the historical borders of Poland. As a result of the study, regions were identified whose cluster shapes corresponded to the borders of historical provinces. While analysing Poland's historical divisions and its urban network, use was also made of the river network, demonstrating which rivers have played the role of a barrier or are a key determinant behind the development of regional settlement networks.

Key words

urban network • cities and towns • clustering • historical geography • GIS • Poland

Introduction

Settlement networks have been investigated by geographers alongside historians, economists, urban planners and researchers representing other disciplines worldwide. In recent years, more extensive research of urban networks has been pursued by such researchers as: Haegen (1982), Pelletier and Delfante (1989), Moriconi-Ebrard (1993, 2000), Renard et al. (1994), Knox (1994), Bensch (1996), Brunet (1996), Pumain and Saint-Julien (1996), Rozenblat (1996), Paulet (2000). The French *La Documentation Française* published an interesting series of atlases on cities, towns and the settlement networks (Pumain 1989). Mathematical methods have been used in research on settlement networks in works by such authors as: Chorley and Haggett (1967, 1969), Haggett

(1973), Grave and Roberts (1980), Chamussy et al. (1994), Douglas et al. (1996), Pumain and Saint-Julien (1996), Béguin and Pumain (1999), Fabriès-Verfaillie et al. (2000), Matei and Pumain (2000), Batty (2001, 2003, 2004).¹ This proves that geographers have been showing continued interest in using mathematical methods in this area. Interesting methods of spatial regionalisation can be found in the latest studies by Assunção et al. (2006), Duque et al. (2007).

Research on the urban network in Poland has had a long-lasting tradition, which was the subject of wide-ranging discussion in a study by Biderman (1994). It must be remembered that the first

¹ The author of this study refers exclusively to the latest publications, as well as those which inspired her to apply the research methods selected.

studies on the topic go back to the years 1918-1939 and were published by Uhorczak (1936-1937), Malicki (1937), Ormicki (1938), Rewieńska (1939). In the post-war period, research on the transformation of the Polish settlement network was initiated by Dzięwoński (1947), Jelonek (1967a,b). Scholars from other Polish universities followed suit. Most of the publications about the urban network in Poland were regional in nature, with only a few addressing the problems on a nationwide scale, including: Dzięwoński (1947), Kiełczewska-Zaleska (1957, 1974), Dangel (1968), Kostrubiec (1971), Szymańska (1992), Koter and Kulesza (1999), Krzysztofik (2005, 2007), Jażdżewska (2006), Parysek (2006), Sokołowski (2006). Studies of regional urban networks were mainly produced for Poland's regions or voivodships² or other territorial units: for Białystok Voivodship – Ormicki (1938), Werwicki (1957), Kosiński (1962), for Lower Silesian (*Dolny Śląsk*) Voivodship – Werwicki (1970), Ciok (1994), for the area of Kalisz and Ostrów Wielkopolski – Maik (1976), for Kuyavia (*Kujawy*) – Szymańska (1982), for the Małopolska Voivodship – Górka (1988, 1996), Soja (2002), for Central Poland – Suliborski (1994), Kulesza and Koter (1998), Jażdżewska (2001), Kulesza (2001), for Opole Voivodship – Kostrubiec (1971), Jakubowicz (1977), Rajman (1986), Heffner (1992), Drobek (1999), for Central Pomerania (*Pomorze Środkowe*) – Rydz and Jażewicz (2005), Rydz (2008), for Poznań Voivodship – Zajchowska (1953), for Silesian Voivodship – Rajman (1970), Petryszyn (2006).

When overviewing the relevant literature, one can see that the range of issues already investigated and lending themselves to investigation through studies of urban networks is huge, and this study fits into this context.

Research question

In 2010, there were 903 towns and cities (Fig. 1) in Poland, which were scattered in a nearly random fashion (Jażdżewska 2008). Consequently, can it be postulated at all that spatial development is a result of historical or natural conditions? The towns and cities were founded between the early 13th century and the beginning of 21st century, with the process still continuing. However,

² The borders of voivodships kept changing, as a result of which it is often difficult to compare studies, e.g.: the Białystok Voivodship in the works by Ormicki (1938) and Werwicki (1957)

it must be remembered that the origins of most of them date back to the Middle Ages (13th-14th centuries), and by the end of the 18th century approx. 65% of the present-day towns and cities had already been established. One would expect their regional historical diversity to be linked to centuries-long political divisions. The search for differences may take various forms. In order to find them the author decided to use a statistical method of group-average hierarchical clustering (Jażdżewska 2008). The taxonomic method used aims to find answers to the following questions:

1) Does Poland have regional urban networks, do they correspond to the historic regions as indicated by the historian Gloger (1903), and to the historical maps of Polish provinces published in the *Historical Atlas of Poland* (Czapliński & Gediga 1998)?

2) What is the role of rivers in the development of the urban network in Poland?

3) What historical processes could have contributed to the present-day form of the Polish urban network?

Research method

The use of mathematical methods for classification purposes was proposed to the scientific world by a Polish scholar, Czekanowski (1913). Initially, mathematical methods were mainly used in the natural sciences. In the following decades, they made their way into a number of other scientific disciplines, including psychology, economics, geology, geography, sociology and others. In geographical sciences, classification procedures have a wide range of applications (Parysek 1979), with spatial classification having been used by Parysek (1982) to analyse geographical space seen as three-dimensional Euclidean space. Taxonomy may not only lead to classification but also to regionalisation. It is delivered by taxonomic procedures in nine steps (Fig. 2) (Kostrubiec 1982).

Hierarchical clustering was used to analyse the settlement network, with towns and cities (shown as dots – with latitude/longitude as properties) and distances between them as the key elements. On the assumption that the distances between towns were relevant in the course of the development of historical regions and the foundation of towns, the group-average method as proposed by Sokal and Michener (1958), was used. According to this method, the distance between



Figure 1. Distribution of cities and towns in Poland in 2010.

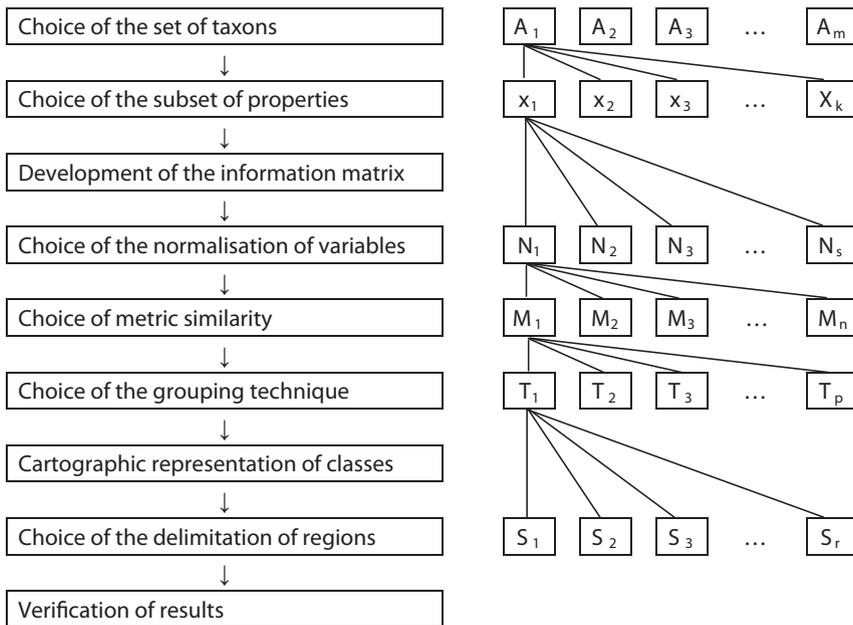


Figure 2. Procedure leading to the identification of uniform areas.

Source: Kostrubiec (1982).

the clusters is calculated as the average Euclidean distance between the elements of these clusters (Kostrubiec 1982). The properties were not normalised.

Source data used in Geographic Information Systems must come up to certain standards. To ensure this, the thematic (vectorial) layers covering the territory of Poland as defined by the coordinate

system of 1992, i.e. the hydrographic network, the network of towns and cities and the administrative borders, were consistent with the standards applied by the MapInfo software. The historical raster maps were calibrated, with the geographical coordinates corresponding to the other vectorial thematic layers. The hierarchical clusters were computed by means of the SPSS software.

SPSS software and MapInfo were used for cartographic calculations and presentation. The steps of the procedure were as follows:

1) A digital map was created, with cities and towns marked as dots.

2) A table of town attributes was created with two fields: latitude and longitude, which show the geographical coordinates of the towns (MapInfo function).

3) Tables of attributes with the town's name, date of foundation, population size, longitude, and latitude for all Polish towns and cities in 2010 were exported to the SPSS software. Geographical coordinates were used for the clustering procedure. The other properties were used for the purpose of the interpretation of the results.

4) In the SPSS software, group-average hierarchical clustering was carried out, with the Euclidean distance as one of the parameters. The algorithm of the procedure is as follows (Grabiński et al. 1989):

- a) it is assumed that each item forms a single-element cluster;
- b) based on the distance matrix D , pairs of clusters p and q are sought ($p < q$) with the smallest distance:

$$d_{pq} = \min \{d_{ij} \mid (i, j = 1, \dots, n; i \neq j),$$

where n is the number of current clusters;

- c) clusters p and q are combined into a new cluster, with the new cluster having number p and cluster q removed. The numbers of clusters above q and the number of clusters is reduced by 1 ($n = n - 1$);
- d) the distance between the new cluster and the other clusters is calculated by the method selected;
- e) steps 2 to 4 are repeated until all the items form a single cluster.

5) Presentation of the results of the calculations is carried out in the form of a dendrogram³,

with 1-25 cluster levels identified⁴. They are used for the spatial presentation of the results of the calculations.

6) At each of the hierarchical levels of town clustering, the clusters are presented on the map as polygons comprising all the towns forming the cluster (in our case MapInfo software was used). The clusters on each level are disconnected, but higher-order clusters are inclusive of lower-order clusters.

7) For each stage of clustering the following are calculated: number of towns clustered and isolated, number of polygons forming clusters of towns and their area. The results are shown in tables.

8) In our study a preliminary analysis of the usefulness of the method for studying settlement networks was carried out.

9) Based on the criteria selected, spatial delimitation and analysis of the urban network were delivered. The clustering of the urban network was compared to the description of Poland's historical borders as provided by Zygmunt Gloger over 100 years ago. Gloger's work (1903) did not show any maps, with the external and internal borders being described narratively. As a result, the comparative analysis was based on a series of historical maps showing 13th–17th-century Poland found in the *Historical Atlas of Poland* (Czapliński & Gediga 1998). This study also analyses the borders and rivers that Jażdżewska (2008) demonstrated in her work, which used a specific mathematical method, have played a role in the development of the urban network in Poland, as well as those river valleys which Gloger (1903) identified as forming parts of its borders.

Analysis of results

Once the group-average hierarchical clustering was used with the Euclidean distance as one of the parameters, as many as 81.5% out of 903 towns and cities had already formed clusters⁵ of 2-12 towns in the first step of the procedure. The largest clusters were found in traditionally industrial areas, notably in Upper Silesia (*Górny Śląsk*). In the second step, only seven towns remained isolated, mainly those lying near the border (Kołobrzeg, Gubin, Łęknica, Włodawa, Terespol, Sejny) and

³ The dendrogram for 903 towns and cities had in total 20 pages and was shortened to show the results from step 4 (Fig. 4).

⁴ The method did not identify several steps in different years.

⁵ Clusters and groups are synonymous in this article.

Bytów. Beginning with the third step, all the towns belonged to one of the 65 clusters identified, these last being uniformly distributed across Poland (Fig. 3).

about their relationship with Poland's historical regions?

The above strongly urbanised clusters do not represent the oldest parts of the urban network

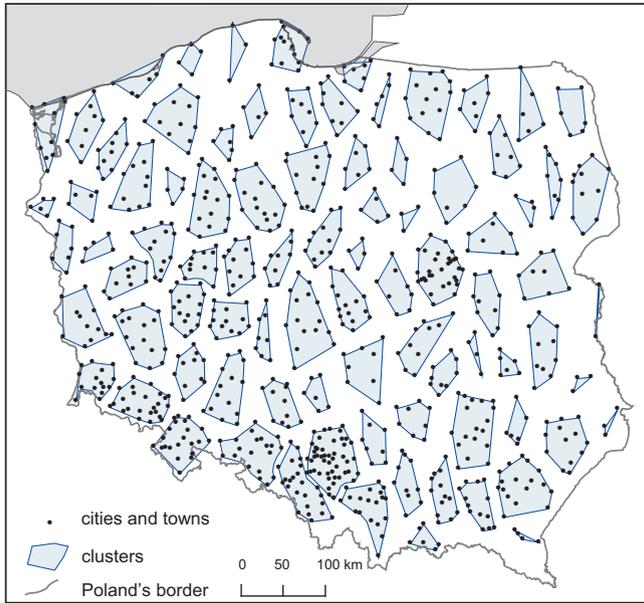


Figure 3. Urban network in Poland in 2010 as divided into clusters (step 3).

They can be analysed according to a range of criteria: level of urbanisation, area of the polygon, number of towns. There were 5 clusters with an urban population of more than 1 million (Tab. 1), covering a cumulative area of 12,900 km². They were formed by 130 towns and cities, with an overall population ranging between 7.5 and 8 million. This means that 4.1% of Poland's area was inhabited by approx. 32% of the country's urban population. The question then arises

in Poland. The development of some Silesian areas, which peaked in the 19th century, was based on heavy industry (mining, metallurgy). The area mainly comprised Upper Silesia and Dąbrowa Basin (*Zagłębie Dąbrowskie*) in which only every fourth town was set up in the 13th-18th centuries, most of them dating back to the 19th and 20th centuries. In the area of Łódź, which is historically linked to the development of the textile industry, half of the towns date back to the

Table 1. Clusters of towns and cities with a population of over 1 million (step 3 of the procedure).

Name of cluster	Largest city	Number of cities and towns	Population in millions	Number of cities with a population of more than 100 thousand	Number of cities with a population between 50-99 thousand
Silesia	Katowice	41	2.5	7 ¹	7 ²
Warsaw	Warsaw	31	2.2	1	2 ³
Silesia-Cieszyn	Gliwice	24	1.0	2 ⁴	1 ⁵
Małopolska	Cracow	19	1.0	1	0
Łódź	Łódź	15	1.0	1	2 ⁶
	Total	130	7.7	12	12

¹Sosnowiec, Bytom, Ruda Śląska, Tychy, Dąbrowa Górnicza, Chorzów; ²Jaworzno, Mysłowice, Siemianowice Śląskie, Piekary Śląskie, Będzin, Świętochłowice, Zawiercie; ³Legionowo, Pruszków; ⁴Bielsko-Biała; ⁵Zory; ⁶Zgierz, Pabianice

13th-15th centuries, but the shape of the cluster was not determined by early historical divisions, but rather by the Łódź conurbation, which dates back to the 20th century. As regards the Warsaw cluster, 22.5% of its towns and cities were founded in the 14th-15th century, and the rest in the 20th-21st centuries, as a result of which the shape of the cluster corresponds to the shape of the Warsaw conurbation, and not to the historical region of Masovia (*Mazowsze*). Only the Małopolska part can be said to correspond to historical divisions, as 60% of its towns were founded in the 13th-18th centuries, with all of them lying within the historical boundaries of the Małopolska region. All of the towns in the Silesian-Cieszyn cluster lie within the old Opole-Racibórz District, with half of the towns established in the 13th-16th centuries. Over a period of 22 years (1951-1973), as many as 13 towns (10 industrial cities and 3 tourist towns) were founded within its historical borders.

By contrast, the five clusters with the largest polygon areas (Tab. 2) show a different distribution in Poland. The largest area of ca. 3,500 km² was that of the Sieradz cluster, located on both sides of the Warta River, in which over 50% of the towns were founded in the 13th-14th centuries, with 25% dating back to the 20th century. It is dominated by small towns with a population of up to 20,000 (60%) and medium-sized cities with a population of up to 50,000. The cluster is an interesting example of how a fragment of the regional settlement network in the Sieradz area, which was part of the Kuyavia Region (*Kujawy*) in the 13th century, has been preserved. The origins of the Sandomierz cluster date back to the medieval Sandomierz Province, which was part of Małopolska. The industrialisation process in the region which took place in the 19th and 20th centuries also

played a part. The oldest towns, which date back to the 13th-14th centuries, represent 27% of the towns and have a population below 25,000. The largest cities (50-75,000 residents), i.e. Ostrowiec Świętokrzyski and Mielec, developed as parts of the Central Industrial District established at the time of the Second Polish Republic (1918-1945). The Opole cluster is part of the medieval Opole-Racibórz District, with 75% of the towns dating back to that period, demonstrating permanence of this settlement network. The Przemyśl cluster lies in full within the Przemyśl Province, which was part of Red Ruthenia (*Ruś Halicka*), which was inherited by King Casimir the Great (*Kazimierz Wielki*) in 1333 and incorporated into Poland in 1344. The towns founded between the 14th and 17th centuries represent nearly 90% of the towns in the cluster, which proves that it owes its shape to historical conditions.

The subsequent steps in the clustering procedure prove the permanence of the regional historical urban networks in Poland, disrupted – in part – by networks of towns set up or developing as a result of the discovery of natural resources (coal, copper, sulphur), centrally planned industrial development during post-war Communist times and the growth of tourist towns.

When analysing the dendrogram (Fig. 4) presenting the successive stages of clustering one, can see that historical regions should not be identified *a priori*, by a pre-imposed step in the procedure, as some of the regions can already be seen in the initial stages, e.g. the Silesian cluster, while others arise later on in the procedure. The first seven steps in the clustering procedure shown in the dendrogram (Fig. 4) and on the map (Fig. 5), reveal 20 regional urban networks in Poland (These networks will be discussed in the order they appear in the dendrogram).

Table 2. Cities clusters with an area of polygon exceeding 3 thousand km² (step 3 of the procedure).

Name of cluster	Largest cities	Number of cities	Population in thousands	Number of cities with a population exceeding 100 thousand	Number of cities with a population between 50 and 99 thousand
Sieradz	Zduńska Wola	15	220	0	0
Silesia	Katowice	41	2,500	7 ¹	7 ²
Sandomierz	Ostrowiec Świętokrzyski	18	287	0	3 ³
Opole	Opole	20	441	1	2 ⁴
Przemyśl	Rzeszów	17	365	1	0

^{1,2} cf. Table 1; ³ Mielec, Tarnobrzeg; ⁴ Kędzierzyn-Koźle, Racibórz

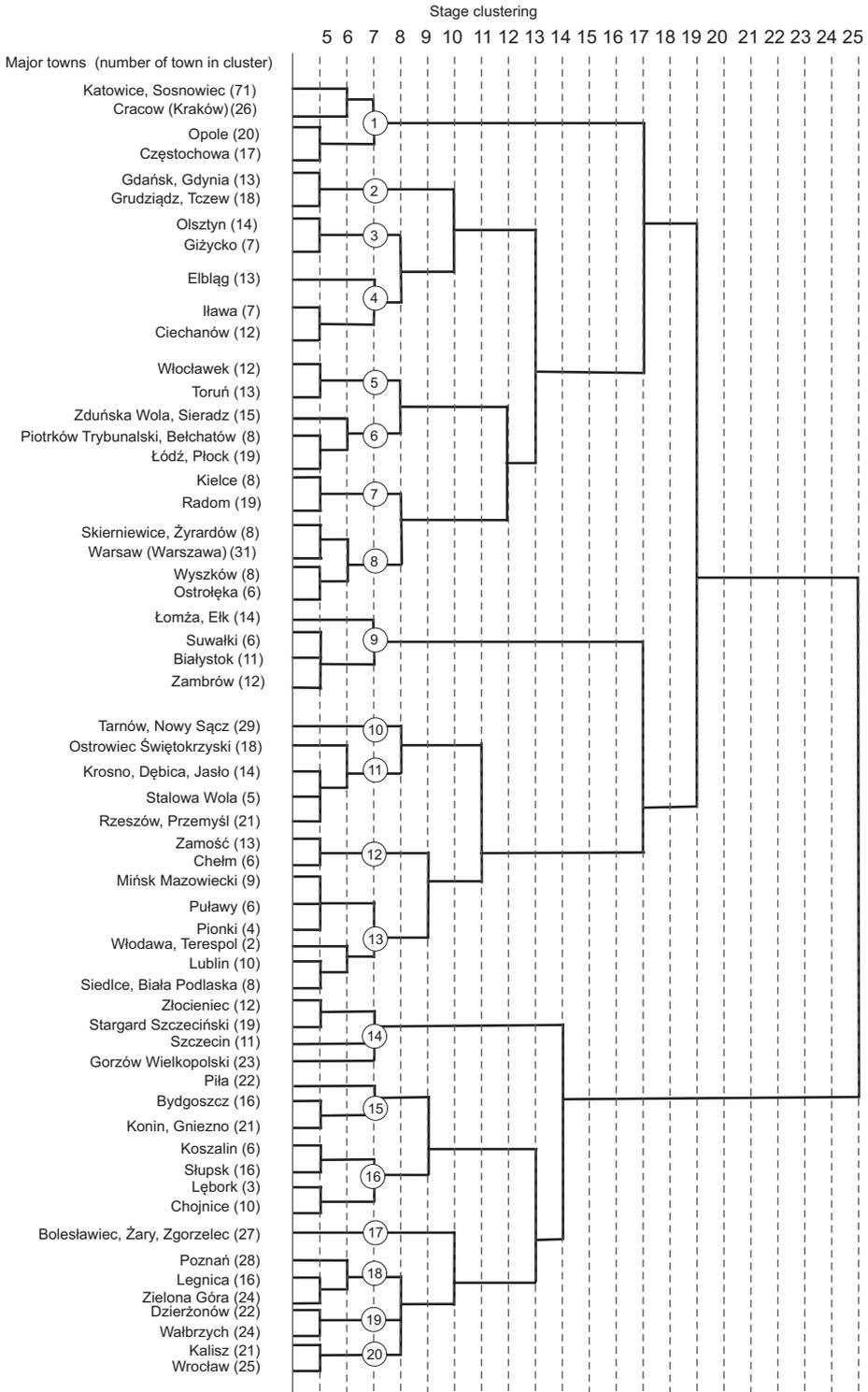


Figure 4. Dendrogram of group-average method and division of the cities and town settlement network in Poland.

Cluster 1 (137 towns and cities – 41% dating back to the 13th-15th centuries) comprises the entire historical Opole-Racibórz District and the western part of Cracow Province, which broke away from its eastern sector (cluster 10). A network of industrial towns (46%), mainly in Upper Silesia, and tourist towns (Zakopane, Ustroń, Wisła), set up in the 20th century, are wedged into the historical area of the cluster. This caused a group of towns of the historical Cracow Province to be absorbed into it.

the delta of the Vistula River and the Hel Peninsula. Cluster 3 includes 21 Masurian towns, while cluster 4 comprises 32 Warmian towns lying in the catchment area of the Pasłęka River, including some Masovian towns located in the basin of the Wkra.

Cluster 5 comprises the entire Chełmno Province stretching between the Vistula, the Osa, the Drwęca, part of Masovia (between the Drwęca and Skra) and northern Kuyavia. The above three clusters join together in the 10th step of the proce-

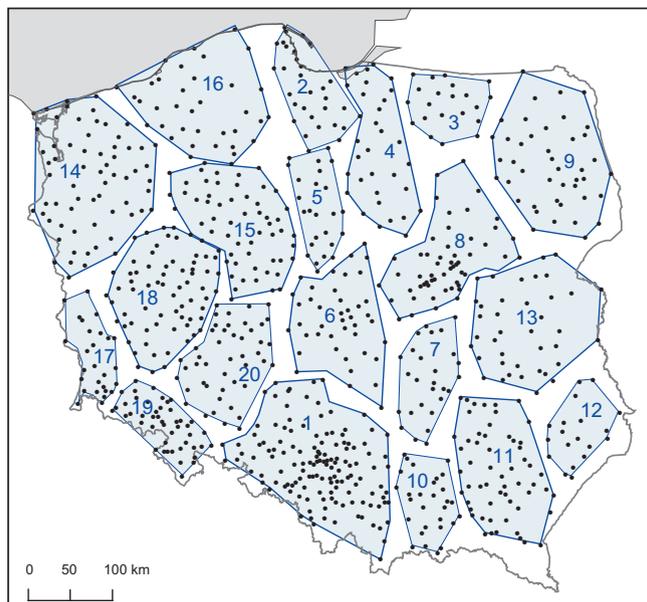


Figure 5. The urban network in Poland in 2010 as divided into clusters (step 7); see legend in Figure 3. Clusters are numbered in accordance with the order of appearance in dendrogram: 1 – Opole-Racibórz District and the western part of Cracow Province; 2 – Gdańsk, Pomerania; 3 – Masuria; 4 – Warmia; 5 – Chełmno Province, Northern Kuyavia; 6 – Sieradz-Łęczyca Province, Southern Kuyavia; 7 – Radom-Kielce cluster; 8 – Masovia; 9 – Podlasie; 10 – Tarnów cluster – eastern part of the Cracow Province; 11 – Przemyśl Province; 12 – part of the Duchy of Chełm-Belz; 13 – Lublin cluster; 14 – Western Pomerania; 15 – Northern Wielkopolska; 16 – Central Pomerania cluster; 17 – part of Łużyce; 18 – Southern Wielkopolska; 19 – Duchy of Legnica and the southern part of the Wrocław cluster; 20 – Kalisz District and the northern part of the Duchy of Wrocław

Cluster 2 (31 towns and cities, with as many as half of them founded in the 13th-14th centuries) consists of the urban settlement Gdańsk Pomerania, as well as towns established by the Teutonic Knights in the 14th century (including Malbork, Kwidzyna, Gniew, Grudziądz). The old medieval network of settlements was 'reinforced' by 20th-century tourist towns (including Sopot, Jastarnia, Władysławowo) and by the port city of Gdynia. However, these latter additions did not change the coverage of the network, which extends over

the delta of the Vistula River and the Hel Peninsula. Cluster 3 includes 21 Masurian towns, while cluster 4 comprises 32 Warmian towns lying in the catchment area of the Pasłęka River, including some Masovian towns located in the basin of the Wkra. Cluster 5 comprises the entire Chełmno Province stretching between the Vistula, the Osa, the Drwęca, part of Masovia (between the Drwęca and Skra) and northern Kuyavia. The above three clusters join together in the 10th step of the proce-

ture (Fig. 4), creating a polygon resembling the former area of East Prussia. Cluster 6 covers southern Kuyavia, i.e. the Sieradz-Łęczyca Province. It also comprises the network of towns of the Łódź conurbation, which does not change the spatial system of the regional settlement network of Kuyavia. These two clusters connect in Step 8 to comprise most of the area of 13th-century Kuyavia (Fig. 4) and the Chełmno Province, for which Poland and the Order of the Teutonic Knights contended for several centuries.

Cluster 7 (Radom-Kielce) stretches over territory known since the 14th century for both mining and industry (Chełciny, Kielce), with more than half of its 27 towns being part of the settlement network of the former Sandomierz Voivodship (between the Pilica, Vistula and Nida Rivers). In the mid-19th and throughout the 20th century, industrial activities developed in the different towns, a development which was fostered, *inter alia*, by the construction of two railway lines in 1885. The two cities of the cluster with a population exceeding 200 thousand, i.e. Kielce and Radom, together with the regional railway line, form the axis of the cluster. Although, as mentioned above, the settlement network was part of the Sandomierz Province for years, the successive steps of the procedure show that currently it forms stronger links with Masovian cities.

The shape of the polygon depicting Masovia (cluster 8) resembles the 13th-century Masovia, which stretched between the Pilica and Bzura Rivers on the left side of the Vistula, and covered the lower reaches of the Narew and Bug Rivers, as well as the latter's confluence with the Vistula. The north-western parts of historical Masovia were not covered by the cluster. Out of the 53 towns located within the cluster, nearly a half received their charters in the 20th century, with most of them being part of the Warsaw conurbation. This means that the Warsaw conurbation has not changed the regional town settlement network of that part of Masovia, but rather has consolidated it.

The north-eastern cluster 9 extends over most of Podlasie (between the Biebrza and Narew Rivers) and several Masurian towns. Towns started to be established here later (in the 15th century) than in other Polish regions. In the 16th century, it formed a borderland area between Lithuania, Poland, the Duchy of Prussia, and in the 19th century – between the Russian Empire, the Duchy of Prussia and the Kingdom of Poland. The shape of the cluster does not align with historical but rather with hydrological divisions. It covers the basins of the Narew and Biebrza rivers, extending from their sources to the Pisa River, which is a right-bank tributary of the Narew. Southern Podlasie was part of the Lublin cluster (13).

Cluster 10 (Tarnów) is small yet visible. It used to be part of the Cracow Province, with its axis formed by the Dunajec River and its tributaries. From the west, it borders on cluster 11 (Przemyśl), from which it is separated by the Wisłoka. It repre-

sents the historical border between Red Ruthenia and Małopolska. The Przemyśl cluster consisting of 57 towns, half of which were established in the 13th-15th centuries, corresponds to the Przemyśl Province, but it 'protrudes' north-west towards Ostrowiec Świętokrzyski. As a result, the town of Sandomierz, which is the capital town of the historical Sandomierz Province, is included in the cluster. This may result from the industrialisation of the area in the 20th century, when plants were set up on both sides of the Vistula as part of the so-called Central Industrial District. In south-east Poland, the shape of cluster 12, one of the smallest clusters and with few towns visible, is also interesting. The polygon comprises the upper reaches of the Wieprz River and corresponds to the area of the Duchy of Chełmno-Belz (15th century). Yet the urban network is a result of another – later – period, when towns were founded by aristocratic families, e.g. the Zamojski's, Leszczyński's, Gorański's (15th-16th centuries). North of this stretches the much bigger Lublin cluster (13), to which was joined the network of towns of southern Podlasie.

The succeeding clusters (from 14-20) represent the network of towns of Western Poland which will join together in the 14th step of the procedure. Cluster 14, visible in the north-west (Fig. 5), represents the towns of Western Pomerania, which were joined by the towns of the Lubusz Province. It constitutes the eastern part of the Brandenburg network, lying on the right side of the Oder River. Out of the 65 towns located within the polygon, 80% were founded as early as the 13th-14th centuries. This proves that the settlement grid there is permanent. The eastern part of the cluster borders on the basin of the Parsęta River, while its southern section stretches over the area where the Warta connects with the Oder, as far as the Pliszka River.

The outline of the historical Wielkopolska region does not emerge as a single cluster. The region's northern part (cluster 15), comprising the catchment area of the Noteć River as far as the Warta River Valley, consists of 59 towns, 62% of which were founded in the 13th-14th centuries, and only 10% in the 20th century. It is one of the oldest regional town settlement networks in Poland, with the former capital town of Gniezno. Cluster 16 lies north of it, stretching between the Baltic, the Parsęta, the Słupia and the Noteć basin. The cluster can be referred to as Central-Pomeranian. Two thirds of its towns date back to the 13th

and 14th centuries. Although established by the Piast Dynasty, they were developing for 600 years within the borders of the German state. The two clusters join together in successive stages of the procedure, uncoupling their links with the historical regions of Poland.

In south-west Poland, there is a fragment of Poland's historical region of Łużyce, with cluster 17, which lies between the Oder, the Lusatian Neisse and the Sudetes (*Sudety*) and corresponds to its shape (Fig. 5). Cluster 18 represents the second southern part of Wielkopolska, lying in the catchment area of the Warta River, which incorporates the historical Głogów Province from the south. Most of its 68 cities were founded in the Middle Ages, with only some established in the second half of the 20th century. Interestingly, the network of towns in southern Wielkopolska – unlike its northern part – connects in the succeeding steps of the procedure with the network of towns in Lower Silesia.

In the Middle Ages, Silesia consisted of several parts (the historical districts of Legnica, Głogów, Wrocław, Opole-Racibórz), the outlines of which may be traced in the polygons representing the individual clusters. Cluster 19 represents the southern part of the town network of the Duchies of Legnica and Wrocław, stretching along the Sudetes. It may be presumed that its shape changed as a result of the development of the mining industry in the area of Wałbrzych and of the network of health resorts in the Sudetes. It is the oldest fragment of the town settlement network in Poland, where the first towns were founded (e.g. Złotoryja in 1211), and with 30% of the urban settlements originating in the second half of the 20th century. Cluster 20 comprises the northern part of the Duchy of Wrocław, with its network of towns lying in the Oder River Valley and stretching to the north as far as the Barycza River valley. It connected with the network of towns of the Duchy of Kalisz, lying in the basin of the Proсна River. The origins of most of the towns date back to the Middle Ages, with only 11% established in the 20th century.

The subsequent stages of town clustering (Fig. 4) do not reflect the historical borders of Polish provinces. The towns of Kuyavia and Masovia grouped with Pomeranian and Masurian towns, which did not belong to Poland for several centuries. Towards the end of the procedure – in its 17th step – the group of towns was joined by the net-

work of towns from the area of Opole, Upper Silesia and Cracow. The towns of Wielkopolska, Central Pomerania and Lower Silesia were grouped in a similar way and were joined by the towns of West Pomerania. The town network of south-eastern Poland clustered separately. The towns of the Podkarpacie, Lublin and southern Podlasie regions absorbed the towns of north-eastern Poland lying on the upper reaches of the Biebrza and Narew rivers (including the Białystok conurbation).

The role of rivers in the development of the town settlement network in Poland

During the subsequent stages of the procedure and analysis of the individual shapes of clusters, attention was paid to the course of those rivers that played a major role in the formation of regional borders (mainly political) and had an influence on the shape of the settlement network. They were either a barrier to or axis of development of the urban network of historical regions.

For instance, the Bóbr River, which is a left-bank tributary of the Oder River, was such a barrier. As it turns out, the Bóbr River and its tributary, the Kwisa, which represent the eastern border of the historical region of Łużyce, continue to play the same role in the present-day network of settlements. Between these rivers and the Lusatian Neisse the towns group into a small cluster representing the historical region (Fig. 6). This is interesting as the historical region of Łużyce occupies a small area on the Polish side – it was originally located on both sides of the Lusatian Neisse. This can still be noticed when analysing the clusters, which proves the importance of the above mentioned rivers.

According to Gloger (1903), the Poznań Voivodship – extending beyond the Noteć – bordered on Pomerania in the north, on the Kalisz Voivodship in the east, on Silesia, near the Barycz River in the south, and on Brandenburg in the west. By comparison, the mathematical clusters of the town settlement network in the area (consisting of three polygons) also reach northwards beyond the Noteć and do not cross the Barycz River, proving that the rivers play a role in determining the settlement network of that part of Wielkopolska (Fig. 6). As far as the Noteć is concerned, it is not the river channel itself but the ice-margin valley that had an effect on the development of the town settle-

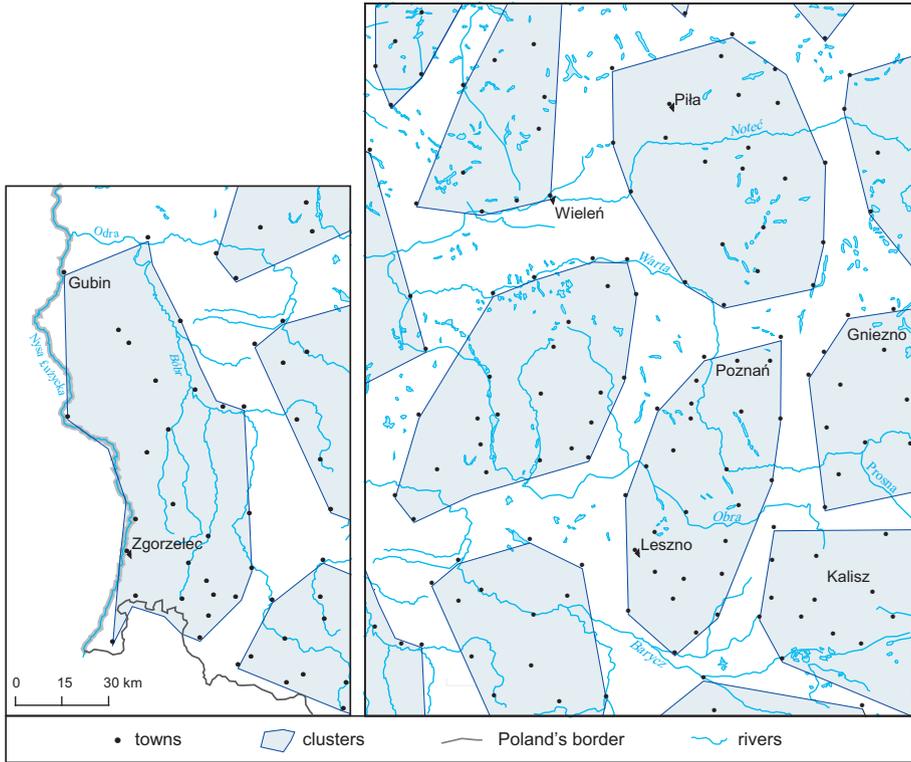


Figure 6. The role of rivers (Bóbr, Lusatian Neisse, Warta, Barycz, Noteć) in town clustering.

ments of the region. The valley of the Noteć River lies precisely along a stretch of the wide Toruń-Eberswalde Valley, the alignment of which might have determined the extent of the northern part of Wielkopolska.

The Prosna River (left-bank tributary of the Warta), which, in its upper reaches, separated the historical regions of Wielkopolska and Silesia, can be seen in the town and cities clustering procedure (Fig. 7). Its role as a barrier between these regions disappears in the succeeding stages of the procedure, as the Kalisz part connects to the cluster of Wrocław. However, it clearly separates the historical Kalisz Province from the Sieradz Province. The middle reaches of the Warta played the role of an axis in the development of the town settlement network of the Sieradz Province (Fig. 7). By contrast, the Gniezno part of the cluster mainly comprises an area on the right bank of the Warta. Its northern section was incorporated by the Kuyavia cluster, with which it will connect permanently in the subsequent stages of the procedure. The mathematical clustering procedure indicates the permanence of the separate historical regions

of Gniezno and Kalisz, but the impermanence of the historical district as a whole.

According to Gloger (1903), Masovia consisted of three voivodships: Płock, Masovia and Rawa. The mathematical town and cities clustering also distinguished 3 polygons in the fourth step of the procedure.

As in Gloger's (1903) conclusions, the Płock cluster borders on the Lidynia (Łydynia) and the lower reaches of the Orzyc River to the east, and on the Płonka River (tributary of the Wkra) to the south. However, the capital city of Płock is no longer part of it, as it grouped with the towns of Kuyavia. The northern border of the cluster reaches farther than in Gloger's description (1903) – as far as the Drwęca River, with the former Prussian towns of Działdowo, Nidzica and Olsztynek joining the network of Masovian towns. The entire cluster is 'innervated' by the Wkra River, which is undoubtedly crucially important for the development of the settlement network in the region (Fig. 7).

According to Gloger (1903), the historical Rawa Voivodship bordered on the Vistula River in the north, the Mogielanka River in the east, and the

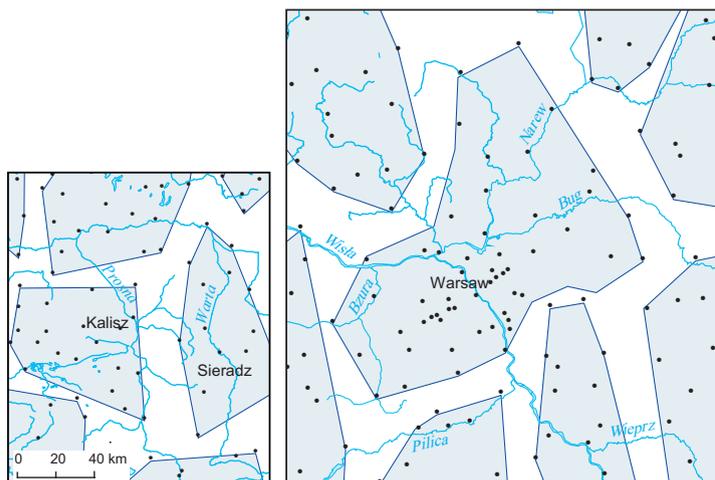


Figure 7. The role of the Prosna and Warta Rivers in town clustering in the Kuyavia, Kalisz and Sieradz areas, as well as of the Vistula, Pilica, Bzura, Bug and Narew Rivers in town clustering in Masovia; see legend in Figure 6.

Pilica River in the south. A stretch of the Przysowa River, to the point where it connects with the Bzura, marked its western border. Similarly to Gloger, the cluster replicates the voivodship borders on the Vistula to the north, on the Pilica to the south, and covers the entire catchment area of the Rawka River and a stretch of the Bzura River. The urbanisation changes that took place in the 20th century around Warsaw, the capital city of Poland, caused the western towns of the Warsaw Voivodship (including the entire Warsaw conurbation of the time) to be incorporated into the Rawa cluster. This reshaped the Rawa and Masovia clusters (Fig. 8). In the subsequent steps of the procedure, the Rawa and Masovia clusters merged, forming a polygon corresponding to the borders of the Masovia region (Fig. 7).

In its middle reaches, the Vistula River brings together the regional settlement network of Masovia, rather than separating it. By contrast, the Pilica River, formerly a natural border between Masovia and the Sandomierz Province separates the clusters along a stretch of its course in a stronger way than the Vistula, which makes it a 'barrier river' obstructing settlement.

In the northern part of Poland, the delta of the Vistula and the lower reaches of the Radunia clearly 'blocked' the grouping of towns in the historical region of Pomerania up to step 4 of the procedure (Fig. 9). In step 5 the polygon visualising the cluster comprises from the north the towns of the Hel Peninsula, the delta of the Vistula River,

part of the Wierzyca River, and with the Osa River marking its border to the south.

The Osa is ca. 50 km long. This small river played an important role as a border river in the Chełmno Province, which was situated between the Vistula, Drwęca and Osa (Gloger 1903). It continues to be a barrier to town clustering (Fig. 9) as it only ceased playing the role of a border river between clusters in the 13th step of the procedure.

The historical region of Warmia had the shape of an irregular triangle with one of the vertexes pointing northwards. In 1241, Pope Innocent IV decreed its borders to be Lake Druzno, the sea and the Pregoła and Pasłęka Rivers (Gloger 1903: 161). Frombork was a cathedral town and the seat of the Chapter of the Warmia Bishopric (Kwiatk & Lijewski 1998). The cluster representing Warmia (Fig. 9) also resembles a triangle, which borders on the sea in the north, on Lake Druzno in the west, and the upper reaches of the Pasłęka River in the east. By contrast, the Pregoła River and the towns lying in its area are currently situated across Poland's border, in Russia. The post-war administrative division caused the settlement network of the historical region to break into several parts, with the parts being reunited in the subsequent steps of the procedure (except for the part lying in Russia).

The former Chełmno Voivodship was situated between the Vistula, Drwęca and Osa Rivers. The Vistula marked its southern and western borders

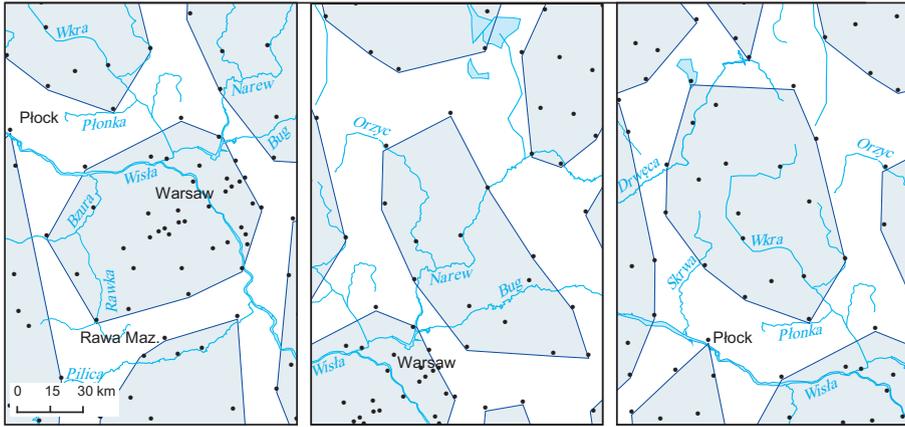


Figure 8. The role of the Vistula, Pilica, Bzura, Wkra, Łydnia, Bug and Narew Rivers in town clustering in Masovia – Plock, Rawa and Warsaw Voivodships (13th century); see legend in Figure 3.

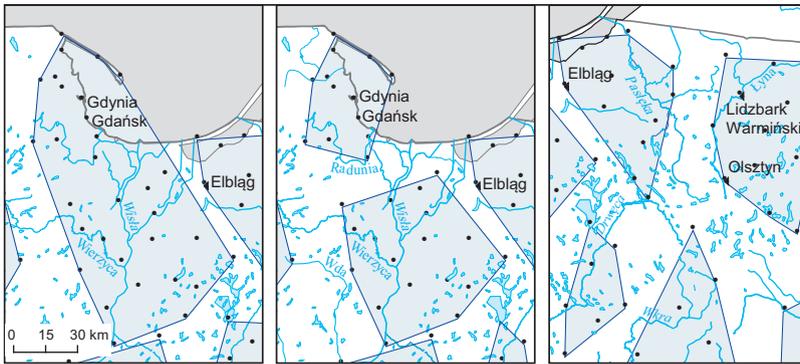


Figure 9. The role of the Vistula, Radunia, Pasłęka, Łyna Rivers in town clustering in Pomerania and Warmia (13th century); see legend in Figure 6.

(Gloger 1903). The cluster corresponding to the historical voivodship incorporated two Kuyavian towns founded in the 20th century (Aleksandrów Kujawski and Ciechocinek). The Osa and parts of the Vistula valley, stretching from Chełmno to Grudziądz, are a barrier to town clustering in the region.

Also in the south of Poland, in the former Małopolska region, formerly separated into the Cracow and Sandomierz Provinces, one can identify rivers still playing an important role in settlement clustering. The town settlement network of the Cracow Province was transformed during the industrialisation of the country, which is also reflected in the mathematically generated clusters. Two clusters make up the settlement network in the region. The eastern Tarnów cluster does not reach the Wisłoka River, which is the natural bor-

der between the areas and the Przemyśl Province (Fig. 10). Its axis is formed by the Dunajec River basin and the Uswicza and Nidzica rivers, as well as the lower Raba. The western Cracow cluster lies on both sides of the Vistula River, covering the upper reaches of the Pilica River in the north, and the Skawa and a section of the Raba in the south. In terms of its shape, it resembles the historical Cracow Province, from which only the towns lying closest to Upper Silesia, e.g. Olkusz, broke away to be incorporated into the Silesian (*Śląsk*) cluster of towns.

In the last but one stage of the hierarchical clustering procedure the settlement network divides longitudinally into two parts (Fig. 11). The borderline between the two parts resembles the 1st-order drainage divide, distorted in the central and southern parts of Poland. It represents the

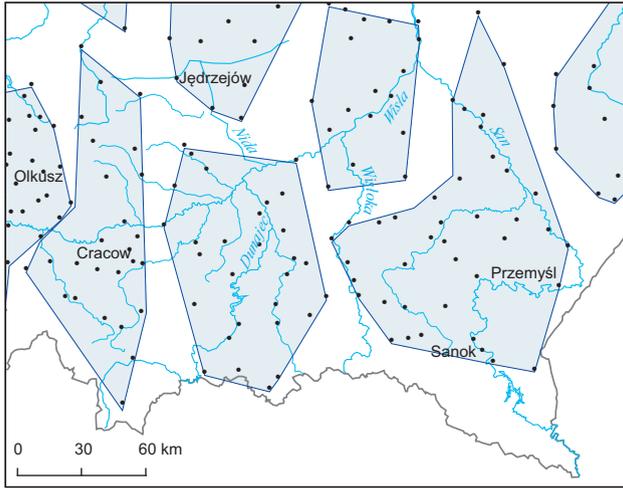


Figure 10. The role of the Vistula, Wisłoka, Nida and San Rivers in town clustering in Małopolska and the Przemysł Province; see legend in Figure 6.

most urbanised area of Poland, where the settlement network changed substantially as late as the 19th and 20th centuries. Both in the Łódź and Upper Silesia parts, many of the towns did not receive charters until Poland industrialised. The Łódź conurbation and the Upper Silesia conurbation align with the 1st-order drainage divide. They form large clusters with towns located both in the Vistula and Oder River basins. This may explain

the shape of the clusters in the last but one stage of the procedure. The eastern cluster, in its southwestern part, incorporates both the Silesian and Łódź clusters.

Conclusions

It must be stressed that, thanks to the use of the group-average method, a large number of clusters

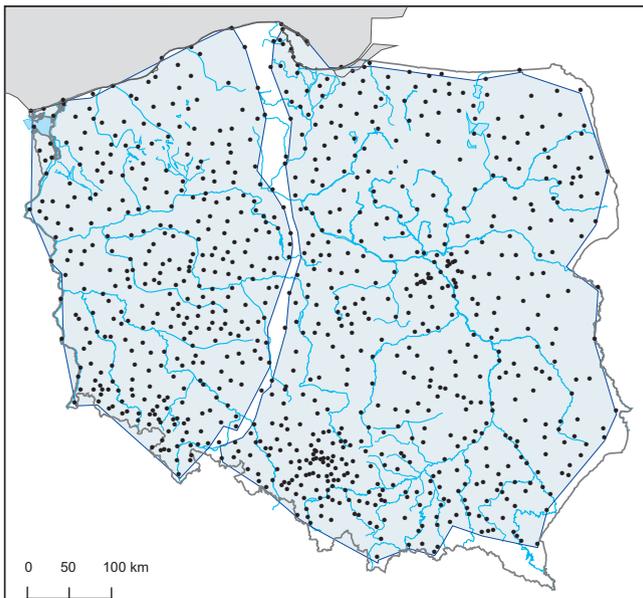


Figure 11. The role of the Vistula and the Oder Rivers in town clustering in Poland in 2010; see legend in Figure 3.

comprising most of the towns were identified from the very first stage. They were evenly distributed across the country and their shape resembled the historical divisions in Poland. Most of the historical regions are reflected in the clusters of towns – e.g. the historical Silesian districts, Wielkopolska, Western Pomerania, Kuyavia, Masovia, Pomerania, Warmia, Podlasie, the Przemysł Province. The towns of the above regions date back both to feudal times and to the industrialisation of the 19th and 20th centuries. They may be identified in the different stages of the procedure (from 1 to 7). At times, it is very hard to explain the town clustering process, as the distribution of towns was determined by many factors, with political and geographical divisions having played a role.

Of all the historical processes that have taken place within the present-day borders of Poland and have determined the development of the town settlement network, the urbanisation processes in Silesia, Wielkopolska, Kuyavia, Pomerania and West Pomerania dating back to the 13th and 14th centuries, and later processes in the other parts of Poland come to the fore. The above urbanisation processes were enhanced by the industrialisation of Poland in the 19th and 20th centuries, which significantly reformed the network of urban settlements in the south of Poland, i.e. in Upper Silesia, Wałbrzych Basin (*Zagłębie Wałbrzyskie*), in central Poland and in the area of Łódź. The development of conurbations, in particular that of Warsaw, which took place at the turn of the 20th and 21st centuries, was another process contributing to the development of the urban network. The network of tourist towns, mainly health resorts, changed

the settlement network to a lesser, though visible, degree.

The location and shape of the clusters shows which rivers played a major role in the development of the urban network in Poland. The role of the Warta and Noteć, in the basins of which the Polish state came into being and in which the first Polish towns were set up, is unquestionable. The Vistula River did not have such a crucial importance along its entire course. A key role was played by its sections with major tributaries, like the San, Narew with the Bug, Drwęca and Osa. The role of the Pilica and the Bzura as barriers to the organisation of the network of towns is also prominent. Clearly, the Wisłoka and the Dunajec played an interesting role, as town clusters can be identified between these rivers, but not along them. A similar situation can be seen between the Wisłoka and the San, the Wieprz and the Bug, and the Lusatian Neisse and the Bóbr.

Thanks to the taxonomic method applied and the tools and software used combined with traditional historical and geographical methods, areas have been identified in Poland where the urban network is still strongly determined by their historical background. This proves that Liszewski was right when he stated in 1994 during a discussion about the shape of the settlement network in present-day Poland that the network “is determined by a number of factors and clearly represents Poland’s cultural heritage” (Liszewski 1994: 98).

Editors’ note:

Unless otherwise stated, the sources of tables and figures are the author(s), on the basis of their own research.

References

- ASSUNÇÃO R.M., NEVES M.C., CÂMARA G., DA COSTA FREITAS C., 2006. *Efficient regionalisation techniques for socio-economic geographical units using minimum spanning trees*. International Journal of Geographical Information Science, vol. 20, no. 7, pp. 797-811.
- BATTY M., 2001. *Polynucleated urban landscapes*. Urban Studies, vol. 38, no. 8, pp. 635-655.
- BATTY M., 2003. *The emergence of cities: Complexity and urban dynamics*. CASA Working Paper Series, Paper 64, London: Centre for Advanced Spatial Analysis, 16 pp.
- BATTY M., 2004. *Hierarchy in cities and city systems*. CASA Working Paper Series, Paper 86, London: Centre for Advanced Spatial Analysis, 26 pp.
- BIDERMAN E., 1994. *Badania sieci osadniczej w Polsce w latach 1918-1993*. [in:] S. Liszewski (ed.), *Geografia osadnictwa i ludności w niepodległej Polsce. Lata 1918-1993. Kierunki badań naukowych*, vol. 2, Łódź: Polskie Towarzystwo Geograficzne. Komisja Geografii Osadnictwa i Ludności, pp. 201-218.
- CHORLEY R.J., HAGGETT P., 1967. *Models, paradigms and the new geography*. [in:] R.J. Chorley, P. Haggett, *Models in geography*, London: Methuen, pp. 19-42.

- CHORLEY R.J., HAGGETT P., 1969. *Network analysis in geography*. London: Edward Arnold, 348 pp.
- CIOK S., 1994. *Rozwój osadnictwa na Dolnym Śląsku po II wojnie światowej. Tendencje i kierunki zmian*. [in:] J. Łoboda (ed.), *Przemiany ludnościowo-osadnicze i społeczno-gospodarcze na Dolnym Śląsku po II wojnie światowej*, Acta Universitatis Wratislaviensis, no. 1591. Studia Geograficzne, no. 61, Wrocław: Wydawnictwo Uniwersytetu Wrocławskiego, pp. 9-49.
- CZAPLIŃSKI W., GEDIGA B. (eds.), 1998. *Atlas historyczny Polski*. Warszawa: Wydawnictwo PPWK, 14th edn., 59 pp.
- CZEKANOWSKI J., 1913. *Zarys metod statystycznych w zastosowaniu do antropologii*. Warszawa: Towarzystwo Naukowe Warszawskie, 228 pp.
- DANGEL J., 1968. *Przekształcenia sieci miejskiej w Polsce pod wpływem rozwoju ludności i uprzemysłowienia kraju w okresie 1946-1960*. Warszawa-Łódź: Wydawnictwo Naukowe PWN, 236 pp.
- DOUGLAS I., HUGGETT R.J., ROBINSON M. (eds.), 1996. *Companion encyclopedia of geography: The environment and humankind*. New York: Routledge, 1021 pp.
- DROBEK W., 1999. *Rola miast zdegradowanych w sieci osadniczej Śląska*. Opole: Wydawnictwo Instytutu Śląskiego, 248 pp.
- DUQUE J.C., RAMOS R., SURINACH J., 2007. *Supervised regionalisation methods: A survey*. International Regional Science Review, vol. 30, no. 3, pp. 195-220.
- DZIEWOŃSKI K., 1947. *Przeobrażenia osadnictwa miejskiego w Polsce*. Czasopismo Geograficzne, vol. 18, no. 1-4, pp. 202-231.
- FABRIÈS-VERFAILLIE M., STRAGIOTTI P., JOUVE A., 2000. *La France des villes. Le temps des métropoles?* Rosny: Bréal, 336 pp.
- GLOGER Z., 1903. *Geografia historyczna ziem dawnej Polski*. Kraków: Spółka Wydawnicza Polska, 387 pp.
- GÓRKA Z., 1988. *Sieć osadnicza*. [in:] J. Warszyńska (ed.), *Województwo tarnowskie – monografia*, Wrocław: Ossolineum, pp. 197-213.
- GÓRKA Z., 1996. *Historyczne zmiany głównych osi osadniczych Małopolski w powiązaniu z ciągami infrastruktury i współczesny układ osadniczy regionu*. [in:] G. Praweńska-Skrzypek (ed.), *Małopolska. Regionalna wspólnota interesów*, Nowy Sącz: Wyższa Szkoła Biznesu, pp. 103-115.
- GRABIŃSKI T., WYDMUS S., ZELIĄS A., 1989. *Metody taksonomii numerycznej w modelowaniu zjawisk społeczno-gospodarczych*. Warszawa: Wydawnictwo Naukowe PWN, 278 pp.
- GRAVE D.M., ROBERTS C.A., 1980. *Principle component and cluster analysis of large towns of England and Wales*. Urban Studies, vol. 17, no. 1, pp. 77-82.
- HAEGEN H. (ed.), 1982. *West European settlement systems*. Acta Geographica Lovaniensia, vol. 22, Leuven: Instituut voor Sociale en Economische Geographie. Katholieke Universiteit Leuven, 370 pp.
- HAGGETT P., 1973. *L'analyse spatiale en géographie humaine*. Paris: Armand Colin, 390 pp.
- HEFFNER K., 1992. *Przekształcenia układu hierarchicznego miast Opolszczyzny*. [in:] J. Łoboda (ed.), *Problemy regionalnych struktur funkcjonalno-przestrzennych*, Acta Universitatis Wratislaviensis, no. 1238. Studia Geograficzne, no. 52, Wrocław: Wydawnictwo Uniwersytetu Wrocławskiego, pp. 149-171.
- JAKUBOWICZ E., 1977. *Lokalne zespoły osadnicze na przykładzie regionu opolskiego*. Acta Universitatis Wratislaviensis, no. 359. Studia Geograficzne, no. 29, Warszawa-Wrocław: Wydawnictwo Naukowe PWN, 71 pp.
- JAŹDŻEWSKA I., 2001. *Miejska sieć osadnicza i jej przemiany*. [in:] S. Liszewski (ed.), *Zarys monografii województwa łódzkiego. Funkcja regionalna Łodzi i jej rola w kształtowaniu województwa*, Łódź: Łódzkie Towarzystwo Naukowe, pp. 225-240.
- JAŹDŻEWSKA I., 2006. *Kształtowanie się miejskiej sieci osadniczej Polski do roku 1918 na tle zmian terytorium kraju*. Acta Universitatis Lodzianensis. Folia Geographica Socio-Oeconomica, vol. 7, pp. 95-121.
- JAŹDŻEWSKA I., 2008. *Przemiany miejskiej sieci osadniczej w Polsce świetle metod matematycznych*. Łódź: Wydawnictwo Uniwersytetu Łódzkiego, 330 pp.
- JELONEK A., 1967a. *Niektóre problemy sieci miast na ziemiach Polski na początku XIX wieku*. [in:] *Zeszyty Naukowe UJ. Prace Geograficzne*, no. 15, Kraków: Wydawnictwo Uniwersytetu Jagiellońskiego, pp. 95-112.
- JELONEK A., 1967b. *Ludność miast i osiedli typu miejskiego na ziemiach Polski od 1810 do 1960 r.* Dokumentacja Geograficzna, no. 3-4, Warszawa: Instytut Geografii PAN, 62 pp.
- KIEŁCZEWSKA-ZALESKA M., 1957. *Problemy geograficzno-gospodarcze małych miast w Polsce w świetle dokonanych opracowań*. [in:] K. Dziewoński, M. Kiełczewska-Zaleska, L. Kosiński, J. Kostrowicki, S. Leszczycki (eds.), *Studia geograficzne nad aktywizacją małych miast*, Prace Geograficzne, no. 9, Warszawa: Instytut Geografii PAN, Wydawnictwo Naukowe PWN, pp. 21-52.
- KIEŁCZEWSKA-ZALESKA M., 1974. *Studia nad strukturą lokalnej sieci osadniczej wybranych obszarów w Polsce. Zaplecze miast Gorlic, Żuromina, Golubia-Dobrzynia*. Dokumentacja Geograficzna, no. 2, Warszawa: Instytut Geografii PAN, 188 pp.
- KNOX P.L., 1994. *Urbanization. An introduction to urban geography*. Englewood Cliffs (New Jersey): Prentice Hall, 436 pp.

- KOSIŃSKI L., 1962. *Miasta województwa białostockiego*. Prace Geograficzne, no. 32, Warszawa: Instytut Geografii PAN, Wydawnictwo Naukowe PWN, 163 pp.
- KOSTRUBIEC B., 1971. *Analiza matematyczna zbioru osiedli województwa opolskiego*. [in:] S. Golachowski (ed.), *Struktury i procesy osadnicze*. Region opolski, Instytut Śląski w Opolu, Opole-Wrocław: Wydawnictwo Naukowe PWN, pp. 9-66.
- KOSTRUBIEC B., 1982. *Taksonomia numeryczna w badaniach geograficznych*. Acta Universitatis Wratislaviensis, no. 589. Studia Geograficzne, no. 38, Wrocław: Wydawnictwo Uniwersytetu Wrocławskiego, 215 pp.
- KOTER M., KULESZA M., 1999. *The plans of medieval Polish towns*. Urban Morphology, vol. 3, no. 2, pp. 63-78.
- KRZYSZTOFIK R., 2005. *Proces kształtowania się sieci miejskiej w Polsce w okresie od XIII do XX wieku*. Czasopismo Geograficzne, vol. 76, no. 4, pp. 383-393.
- KRZYSZTOFIK R., 2007. *Lokacje miejskie na obszarze Polski*. Dokumentacja geograficzno-historyczna. Prace Naukowe Uniwersytetu Śląskiego, no. 2484, Katowice: Wydawnictwo Uniwersytetu Śląskiego, 160 pp.
- KULESZA M., 2001. *Morfogeneza miast na obszarze Polski Środkowej w okresie przedzobiorowym: dawne województwa łęczyckie i sieradzkie*. Łódź: Wydawnictwo Uniwersytetu Łódzkiego, 275 pp.
- KULESZA M., KOTER M., 1998. *Kształtowanie się sieci miast na obszarze Polski Środkowej*. [in:] A. Werwicki (ed.), *Transformacja społeczno-ekonomiczna Polski Środkowej*, Łódź: Wydawnictwo Uniwersytetu Łódzkiego, pp. 17-38.
- KWIATEK J., LIJEWSKI T., 1998. *Leksykon miast polskich*. Warszawa: Muza, 1103 pp.
- LISZEWSKI S., 1994. *O hipotezach przekształceń systemu osadniczego w Polsce w warunkach transformacji*. [in:] A. Stasiak (ed.), *Podstawowe węzły układu osadniczego Polski*, Biuletyn KPZK PAN, no. 167, Warszawa: Komitet Przestrzennego Zagospodarowania Kraju PAN, pp. 97-101.
- MAIK W., 1976. *Analiza funkcjonalna sieci osadniczej podregionu kalisko-ostrowskiego*. Seria Geografia, no. 11, Poznań: Wydawnictwo Naukowe Uniwersytetu Adama Mickiewicza, 112 pp.
- MALICKI A., 1937. *Położenie geograficzne miast na Nadbużu*, Czasopismo Geograficzne, vol. 5, iss. 1, Lwów: Zakłady Graficzne Książnica-Atlas, pp. 18-42.
- MORICONI-EBRARD F., 1993. *L'urbanisation du Monde depuis 1950*. Paris: Economica, 372 pp.
- MORICONI-EBRARD F., 2000. *De Babylone à Tokyo. Les randes Agglomérations du Monde*. Paris: Ophrys, 344 pp.
- ORMICKI W., 1938. *Miasta w województwie białostockim*. Wiadomości Geograficzne, no. 2, pp. 48-59.
- PARYSEK J., 1979. *Zastosowanie analizy skupień w badaniach rozmieszczenia osiedli*. [in:] Z. Chojnicki (ed.), *Struktura i funkcje układów przestrzenno-ekonomicznych*, Seria Geografia, no. 18, Poznań: Wydawnictwo Naukowe Uniwersytetu Adama Mickiewicza, pp. 27-36.
- PARYSEK J., 1982. *Modele klasyfikacji w geografii*. Poznań: Wydawnictwo Naukowe Uniwersytetu Adama Mickiewicza, 223 pp.
- PARYSEK J., 2006. *Miasta polskie w okresie globalizacji*. [in:] J. Stodczyk, E. Szafranek (eds.), *Kierunki przekształceń struktury gospodarczej i społeczno-demograficznej miast*, Opole: Wydawnictwo Uniwersytetu Opolskiego, pp. 11-32.
- PAULET J.P., 2000. *Géographie Urbaine*. Paris: Armand Colin, 315 pp.
- PELLETIER J., DELFANTE CH., 1989. *Villes et urbanisme dans le monde*. Paris: Armand Colin, 199 pp.
- PETRYSZYN J., 2006. *Nowe ośrodki powiatowe w regionie śląskim*. [in:] J. Stodczyk, E. Szafranek (ed.), *Kierunki przekształceń struktury gospodarczej i społeczno-demograficznej miast*, Opole: Wydawnictwo Uniwersytetu Opolskiego, pp. 191-202
- PUMAIN D., 1989. *Atlas des Villes de France*. Paris: Documentation Française, 175 pp.
- PUMAIN D., SAINT-JULIEN T., 1996. *Urban Networks in Europe*. Montrouge (France): John Libbey Eurotext, 252 pp.
- RAJMAN J., 1970. *Zmiany w sieci miast aglomeracji wielkoprzestrzennej Górnośląskiego Okręgu Przemysłowego*. Folia Geographica. Seria Geographica-Oeconomica, vol. 3, Kraków: Komisja Nauk Geograficznych PAN, pp. 83-96.
- RAJMAN J., 1986. *Sieć miejska Opolszczyzny jako strefa brzeżna aglomeracji górnośląskiej*. [in:] K. Heffner (ed.), *Studia nad przekształceniami sieci miast województwa opolskiego i ich przestrzennym rozwojem*, Opole: Instytut Śląski, 145 pp.
- RENARD C., HAUTOIS A., DAMETTE F., VIRE E., HIDE S., 1994. *La France en villes*. Paris: Documentation française, 271 pp.
- REWIENSKA W., 1939. *Rozmieszczenie miast i miasteczek w północno-wschodniej Polsce*. Przegląd Geograficzny, vol. 18, no. 2, pp. 101-132.
- RYDZ E., 2008. *Social, demographic and settlement transformations in the coastal agglomerations*. Baltic Coastal Zone, vol. 12, pp. 125-142.
- RYDZ E., JAŻEWICZ I., 2005. *Współczesne procesy urbanizacji na przykładzie wybranych miast Pomorza Środkowego*, [in:] I. Jażdżewska (ed.), *Współczesne procesy urbanizacji i ich skutki*. XVIII Konwersatorium Wiedzy o Mieście, Łódź: Wydawnictwo Uniwersytetu Łódzkiego, pp. 211-222.

- SOJA M., 2002. *Przyrost rzeczywisty ludności miejskiej Karpat w latach 1978-1998 a struktura wielkościowa miast*. [in:] J. Słodczyk (ed.), *Demograficzne i społeczne aspekty rozwoju miast*, Miasta w okresie przemian, Opole: Wydawnictwo Uniwersytetu Opolskiego, pp. 37-46.
- SOKAL R.R., MICHENER C.D., 1958. *A statistical method for evaluating systematic relationships*. University of Kansas Science Bulletin, no. 38, pp. 1409-1438.
- SOKOŁOWSKI D., 2006. *Funkcje centralne i hierarchia funkcjonalna miast w Polsce*. Toruń: Wydawnictwo Uniwersytetu Mikołaja Kopernika, 276 pp.
- SULIBORSKI A., 1994. *Struktura i rola funkcji przemysłowych miast w integracji miejskiej sieci osadniczej województwa piotrkowskiego*. [in:] M. Koter, A. Suliborski (eds.), *Kształtowanie się struktury funkcjonalno-przestrzennej oraz więzi regionalnych województwa piotrkowskiego*, Acta Universitatis Lodzensis. Folia Geographica, no. 18, Łódź: Wydawnictwo Uniwersytetu Łódzkiego, pp. 55-76.
- SZYMAŃSKA D., 1992. *Przemiany miejskiej sieci osadniczej województwa bydgoskiego, toruńskiego i włocławskiego*. Acta Universitatis Nicolai Copernici. Geografia, no. 26, Toruń: Wydawnictwo Uniwersytetu Mikołaja Kopernika, pp. 91-98.
- UHORCZAK F., 1936-1937. *Miasta w Polsce. Ilość, wielkość, rozmieszczenie z 23 mapkami*. [reprint from a monthly] "Zbliża i Zdaleka", no. 9-10 (1936) and no. 1 (1937), Lviv.
- WERWICKI A., 1970. *Rozwój miast i osiedli miejskich jako wyraz ich funkcji*. Przegląd Geograficzny, vol. 42, no. 2, pp. 267-201.
- ZAJCHOWSKA S., 1953. *Rozwój sieci osadniczej okolic Poznania (XI-XX w.)*. Przegląd Zachodni, vol. 9, pp. 6-8.