APPLYING CHOREMS IN THE CARTOGRAPHIC PRESENTATION OF BARRIERS TO SOCIO-ECONOMIC DEVELOPMENT IN POLAND

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Abstract: This paper presents the theoretical axioms of chorems based on cartographic semiotics. Employing geometric and functional elements and the cartographic state-of-the-art, a regional, national chorem has been created. This chorem portrays the barriers to Polish regional development. It depicts the main development centres, industrial areas and zones of constraint created by the country's external borders, borders of the European Union (EU) and major rivers. The paper also defines chorematic affordance as the dynamic and processual feedback between the domain expert and the geographical or socio-economic processes. The elaborate chorematic diagram contributes not only to cartographers and geographers but also to public administration dealing with sustainable development, as it is intricately tied to regional development, emphasising the crucial importance of effective land management, equitable land distribution and sustainable development.

Keywords: chorem, chorematic diagrams, models, geospatial information, spatial development

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Introduction

Chorem (fr. *chorème*) is a synthetic form of cartographic presentation that focuses through a lens on scenarios related to spatial patterns and relationships, such as political, demographic, economic, spatial organisation and dynamics, globalisation and other issues. Using visual metaphor, it provides a highly effective approach helping users find facts and new patterns. To date, chorems have been studied from the perspective of geovisualisation, automatisation possibilities, traditional cartography, effectiveness analysis, user needs and decision-making. It is believed that chorems well represent knowledge related to spatial location, facilitate visual summaries of data, and could ultimately be used to create a new input for spatial databases. Chorematic diagrams are considered as decision support tools, particularly for geoinformation domain experts to provide quick and comprehensive answers in critical situations. They are also recognised as operational inference tools for modelling geographic space (Del Fato et al. 2008). The term, coined

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by Brunet (1986b), is a neologism composed of the Greek word χώρα, indicating space, territory, place, and the suffix *-ème* from a meaningful component of a linguistic expression, such as a morpheme. The name chorem (Brunet 1993) is given to the basic structures of spatial order, while the combination of these chorems produces a specific organisation of particular space. Synonyms for *chorème* are chorem (Brunet's original anglicisation), chorematic diagram (Reimer 2010, Reimer, Dransch 2009) and chorematic map (De Chiara et al. 2011). Chorem's theoretical foundations are based on geometric primitives (point, line, polygon) and a few composition rules, represented flow (dynamics, symmetry, intensity), passage (e.g. bridge, crossing), polarisation and gradient (dissymmetry, attraction, repulsion). As Brunet (1986b) notes, in his flag publication, chorems 'upraise a new cartographic language' by identifying and emphasising the order as well the role of phenomena and processes in a given area or place.

This paper aims to outline the chorem theoretical axioms and applications supplemented by the chorematic map, which are the author's proposals, namely a regional chorem that presents the problem of uneven Polish regions' development. Furthermore, inspired by the landscape affordance developed by Kempf (2020), we define the concept of chorematic affordance as dynamic and processual feedback between an expert (e.g. cartographer, geographer, spatial planner) and geographical or socio-economic processes. The theory of affordances, formulated by James J. Gibson (after Passia, Roupas 2021), states that the environment is perceived in terms of geographical features, phenomena, and spatial relationships, as well as possibilities for action, called affordances. The communication systems used by a chorem, a synthesised map, have properties and affordances that support the representation of reality. Chorematic affordances contribute to faster decision-making in resource management, land use strategies, and sustainable spatial planning.

Chorem methodological framework

Brunet (2001) notes that the concept of a model appeared in geography as early as the 1960s and is often used to explain and understand phenomena and spatial relationships. Geographers often use models in their research, both mathematical and cartographic, which undoubtedly include chorems. As a cartographic model of a given area, chorem uses symbols to illustrate spatial arrangements and relationships; however, these symbols are not unified despite the theoretical basis defined by Brunet (1980, 1986a, b, 1990). Using generalisations, chorem describes the uniqueness of each place and geographical feature through general geometric, topological and thematic features. As Dhieb (2020) notices, chorem consists of terms and graphics largely abstracted from actual objects and cartographic symbols, which requires a thorough understanding and knowledge of the territory to design the chorem map incomprehensibly. Brunet (1993) distinguishes four types of chorem models: a general model, a regional model, a specific model and an elementary model. The general model is based on theoretical or quantitative geography and is often expressed as a mathematical formula and graph (e.g. von Thunen's gravity model). It could be applied to any area of the world. The regional model is characterised by the limited thematic scope and spatio-temporal range. Unlike the general model, it is not based on laws or theoretical rules but represents the actual existing spatial structure of a given region. The specific model portrays a single organisation; it represents a specific and unique organisation (city, region) and is not transportable. The function of the specific model is completely different from the previous ones – it is not intended to compare objects, but to capture the structure of the object itself. Finally, the fourth type of model, the elementary one, represents the basic structure of a given area, the combination of which expresses the infinite diversity of real situations. As Brunet (1993) points out, some general and even some regional models are also elementary models, and the latter could also be used as general models.

Reimer and Dransch (2009) find that one of the main advantages of chorems is their closer connection to a mental model of geographic space than to a typical thematic map. This nearer relationship concerns both an expert (e.g. spatial analyst), who effortless expresses his mental model with chorem, and a reader who easily understands it. Chorematic maps also highlight the problem of trust placed in the analysis that leads

to the mental spatial model. Deffontaines et al. (1990) emphass that chorems should be seen as a tool for operational reasoning. The researcher uses knowledge to understand phenomena and processes, which is then interpreted and formalised in the form of chorem and made available to other experts. However, this idea has many opponents who criticise it from an epistemological, procedural and cartographic point of view. Oversimplification can lead to a situation where arguments are not built on the convergence of facts and observations but are constructed with arguments that please the authorities (Giblin-Dellvalet 1995). Wanicz (2000) claims that the terminology surrounding choremetic diagrams (maps) is in a constant state of flux so that one cannot be sure which word means what. Chorem, model, carte-model, and iconic model have all been used, sometimes for the same thing, sometimes to differentiate. Furthermore, according to de Maximy (1995), choremetic maps are useful tools as long as the symbols remain decipherable and the methods of analysis leading to their formulation are transparent. Notwithstanding the criticisms, chorems are widely used to study territorial development (Brunet 1986a,b), agriculture (Brunet 1980a, b, Laurini et al. 2007), hydrology (Laurini et al. 2006) and demography (Cherni 2015). They are frequently employed, especially in GIP RECLUS publications (e.g. La Géographie Universelle 1990–1996 in 10 volumes, entirely illustrated with chorems, as well as atlases of Brazil 1986, 1992, World atlas of free zones and tax-free heavens – *Atlas mondial des zones franches et des paradis fiscaux* 1986, atlases of Laos 1989, Cerrados of Brazil 1992, Multinational Corporations 1990–1991, Vietnam 1994 and Singapore 1992). They vary in type, degree of generalisation and symbol used, and are mainly published in *Mappemonde*, a journal founded in 1986 by Roger Brunet and Robert Ferras. One of the most frequently quoted in the literature is the regional chorem of France (Laurini et al. 2007, Fig. 1). The red lines represent the Alps as a frontier towards Italy and Pyrenees towards Spain. The big circle filled in brown shows the Massif Central forcing traffic to follow the Rhone axis. Major transportation axes are shown in black lines, and coastline in blue. The chorem underlines the western part of France as less developed (Laurini et al. 2007).

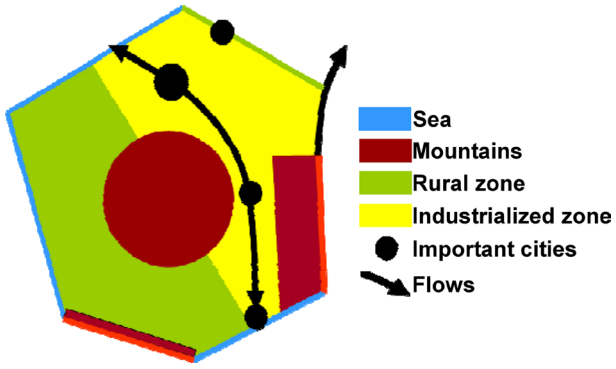
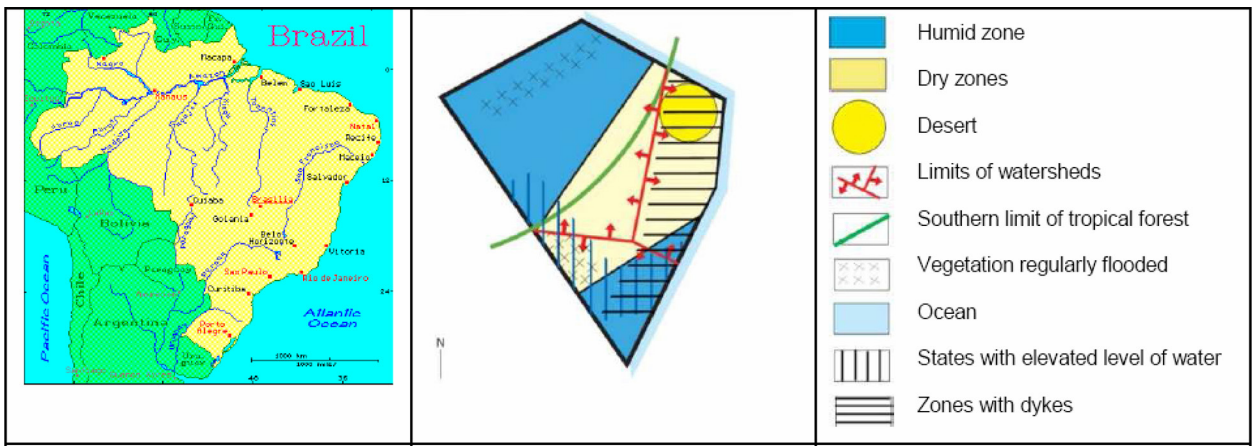


Fig. 1. Chorem of France (Laurini et al. 2007).

Figure 2 illustrates Brazil, where the first map (Fig. 2a) shows a conventional map of main rivers at a small scale, which in principle is of little use for environmental decision-making. The second map (Fig. 2b) represents a specific chorem



(a) Conventional map of rivers in Brazil | (b) Choreme for water problem in Brazil | (c) Caption of choreme (b)

Fig. 2. Chorem of Brazil (Laurini et al. 2006).

for the water problem in Brazil. The legend (Fig. 2c) makes it possible to find where the wet and dry zones are, where water is scarce, where dikes are located and where water demand is higher. Finally, the authors (Laurini et al. 2006) conclude that this kind of drawing is much more informative for any decision-maker than the conventional river map.

Chorems have been used a lot in social geography; a famous example called 'blue banana' (Fig. 3) highlights the main axis of economic and social development in the European Union (EU) and the fact that Paris is in danger of being excluded (Reimer 2010, Bouattou et al. 2017). The 'banana' shape depicting the major economic growth corridor of the EU is a very good example to demonstrate the effectiveness of the use of chorems.

In the age of computerisation and widespread access to spatial data, applications have been developed for the creation of chorems, extending their functionality to include interactive functions and animation (de Fato et al. 2008, Laurini 2009, Lopez et al. 2009, Reimer 2010, Cherni et al. 2015, Bouattou et al. 2017). The chorem map given in Figure 4 illustrates internal migration in Tunisia and was created automatically by the chorem visualisation system ChorML. The receiving and sending cities are represented by circles; their sizes (measured in ordinal scale) vary according to

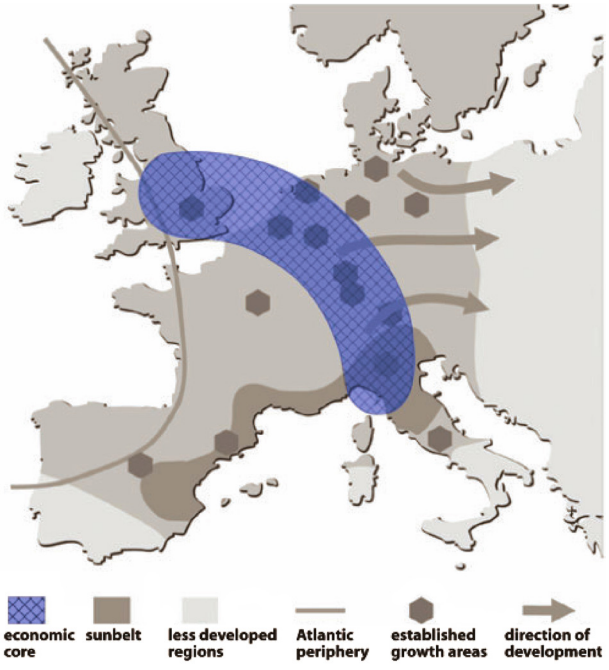


Fig. 3. 'Blue banana' chorem of European Union (Reimer 2010).

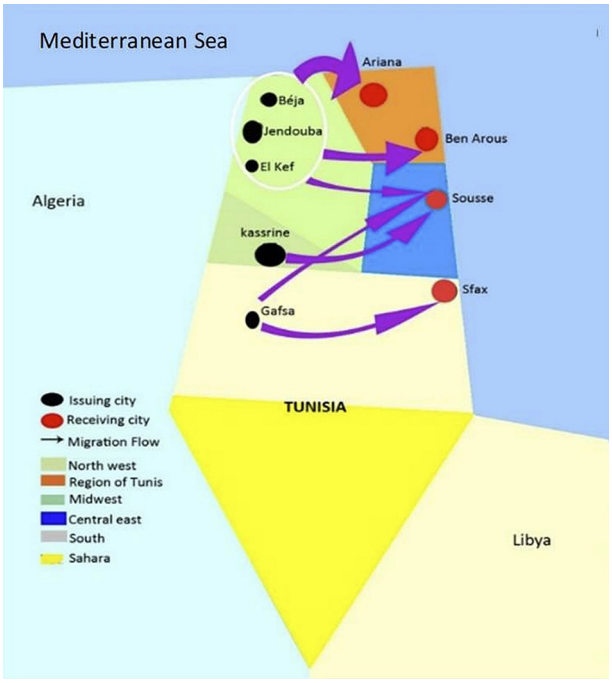


Fig. 4. Migration in Tunisia (Cherni 2015).

the number of immigrants or emigrants and the arrows of variable thicknesses represent the flow of people. The northwest sends large numbers of migrants from other regions while receiving almost constant numbers of arrivals. A high percentage of individuals leaving the governorate of Jendouba, Kef and Béja move east. From Kassrine and Gafsa, migrations are targeted in particular towards Sousse, Monastir and Sfax.

Of particular note are the chorems showing temporal and spatial changes in French cities, including Aix-en-Provence, Angers, Poitiers and Tours (Fleury 2004). By 2010, a standard of signs for choromatic urban studies has been developed, defined as choro-choromatic (Djament-Tran, Grataloup 2010).

Poland is shown on two choremic maps created by Brunet (1986a,b), titled 'In Poland, that is to say nowhere' after 'Ubu the King, or the Poles' (fr. *Ubu Roi ou les Polonais*), a drama of Alfred Jarry. Analysing the history of Poland, administration structure and topography, Brunet (1986a,b) found a principle of space organisation based on the interaction of latitudes and longitudes and regional differentiation. Finally, Brunet observed that Poland's spatial structure comes from the simultaneous play of north–south zoning, and west–east shifts of its gravity centre (Fig. 5). The division into east–west zones results mainly from Germanic pressure and its

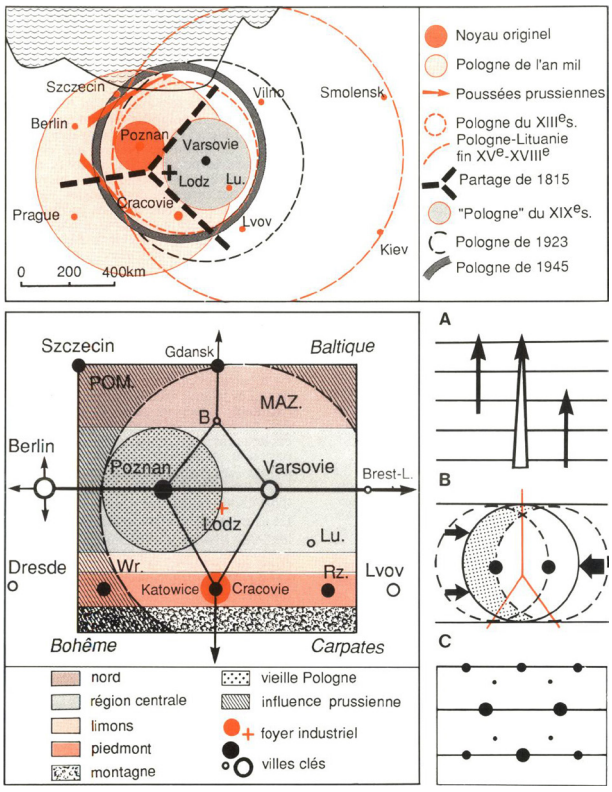


Fig. 5. Brunet choremes titled 'In Poland, that is to say nowhere' (Brunet 1986b).

counterattacks from Lithuania and Russia and has a historical dimension. The borders of Poland in certain historical periods are simplified to circles. What distinguishes this map is a linear scale, very rarely marked on chorems. According to Brunet (1986a,b), Greater Poland together with Poznań and Gniezno (former capital) is a traditional Polish fortress. Kraków is another stronghold of Polishness.

By presenting two original chorems, our paper contributes to the popularisation of this form of cartographic presentation and a different, general and synthetic view of Poland and its capital.

Materials and methods

The research process of chorem-making follows the general assumption of cartographic semiotic theory and refers to the identification of the symbolic nature of maps based on syntactics, semantics and pragmatics. The syntax of chorems, according to Brunet's rules (Brunet 1990), comprises three geometric elements (area, line, point) and four functional arrangements such as flow, passage, polarisation and gradient. The semantic content is expressed by the location of the signs and the visual variables that highlight their meaning. The main idea reveals the affordance of chorematic signs, which facilitates the communication function of a map (a pragmatic aspect).

The developed chorem map 'Poland Development Barriers' is intended for users who would like to broaden their knowledge on the geographical distribution of problem areas related to socio-economic obstacles resulting from suburbanisation, peripherality, location in border zones, etc. Its form, an analogue map, and size are adapted to the typical size of maps in scientific publications and the Statistical Atlas of Poland, to facilitate reference to other sources of information on the factors of uneven development of Polish regions.

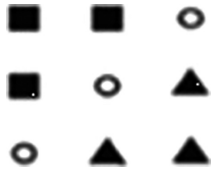
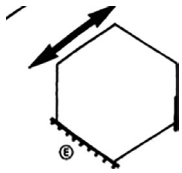
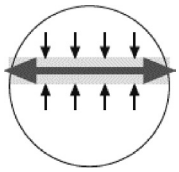
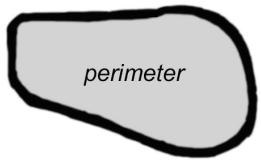
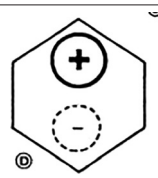
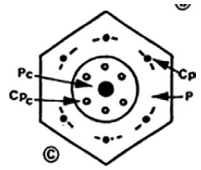
Table 1. Data sources and indicators used.

Data sources	Indicator
Delimitation of problem areas in Poland (Śleszyński et al. 2017)	Problem areas in Poland
Delimitation of the Functional Urban Areas around Poland's voivodship capital cities (Churski et al. 2023)	External zones to Functional Urban Areas around the voivodship cities
Spatial differentiation of the Poland population standard of living (Majka 2015)	Hellwig's development indicator
Demographic Atlas of Poland (GUS 2017)	Population density, urbanisation rate, net migration for permanent residence, share of population accounted for by people of post-productive age (60/65+ years), unemployment
Statistical Atlas of Poland (GUS 2018)	Satisfaction with Life Index, Gross Domestic Product (GDP) per capita, border traffic-rate of impact, economy – entrepreneurship, forest area, pollutions
Incomes and living conditions of the population of Poland– report from the European Union-SILC survey of 2022 (GUS 2023)	The at-risk-of-poverty rate after social transfers by Nomenclature of Territorial Units for Statistics 2 (NUTS 2) in 2022
Land cover changes and flows in the Polish Baltic coastal zone: A qualitative and quantitative approach (Bielecka et al. 2020)	Net changes in forest, agriculture and artificial areas

The study was executed in three stages. The first stage aims to answer the question of what problem(s) the chorem presents and how it can be visualised as well as to collect the necessary materials, maps and statistics. The problem is defined in the Introduction section and notes uneven development of Polish regions. Data obtained from the official website of the Central Statistical Office (GUS 2017, 2018) and selected research papers are summarised in Table 1.

The second stage is to build up expertise and study information on the given area and theme. Then, based on data interpretation, the most important cities or places, attractive and repulsive

Table 2. Function used (based on Bertin 1967, Brunet 1993, Ducruet 2006).

Chorems elementary functions	Graphical signs	Comments	References to Bertin visual variables
Specialised		Indication of the cities' functions (*capital, port cities/groups of port cities, other important cities*)	Shape, colour, size, value
Gradient		Zones of influence: the magnitude of the impact is illustrated by the brightness (*impact zones of major cities*)	Value (lightness), size, colour, shape
Closure		Closed boundary (*country borders*) and aperture (e.g. sea)	Colour, shape, size, orientation, grain, value
Axis and its derivations (tropism)		Line of limitations and obstacles (*rivers*)	Colour, shape, size, orientation, value
Surface		Area representing the chosen phenomenon (*industrial area, urbanisation lag, transformational shock, internal periphery*)	Colour, value, size, grain
Trend surface		Areas in which the phenomenon is observed to be developing in a particular direction (*direction of area exclusion with: urbanisation lag, transformational shock, internal periphery, direction of area exclusion*)	Colour, shape, size, orientation, grain, value
Dissymmetry		Centre of growth versus repulsiveness area	Size, shape, colour, value
Gravitation		Centre-periphery model	Size, shape, colour, orientation, value

locations and socio-economic flows are highlighted. The selection of cities is based on the work of Churski et al. (2023). It was decided to present only cities with the largest urban functional area, which included Warsaw (the capital), Kraków (the former capital), major academic centres such as Wrocław, Poznań, Tricity (Gdańsk, Gdynia, Sopot), Łódź, Szczecin and Katowice (centre of the Upper Silesian Industrial District). Urban impact zones were determined using the Huff and Reilly gravity and potential methods (Zgliński 1994).

Finally, the third stage relies on chorem-making using Brunet's rules (Brunet 1993) and Bertain's (1967) visual variables, position, size, shape, value, colour, orientation and texture (Table 2). Position denotes spatial location both directly and indirectly, while shape represents the outline of an object or spatial phenomenon and can be highlighted with further variables such as size, colour, value or structure indicating the quantitative and qualitative features of the mapped area.

A point as a cartographic sign is assigned to cities, a line to borders and major rivers and a polygon to zones of influence, exclusion or obstacles. Colour and value (lightness) as visual variables differentiate the type of zone (urbanisation lag, transformation shock, internal periphery), while lightness indicates the level of city's influences.

Poland, a Central European Country, covers an administrative area of 312,722 km^2, and is the ninth-largest country in Europe. The country borders Slovakia and the Czech Republic in the south, and Germany in the west, Lithuania and Russia in the north-east, Belarus, and Ukraine in the east. The eastern frontier is both the EU and the Schengen area border. With a population of over 38 million, Poland is the fifth-most populous member state of the EU. Warsaw, the capital city, and other major cities such as Kraków, Wrocław, Łódź, Poznań and Gdańsk are cultural, educational and economic centres. About 60% of the population lives in urban areas and 40% in rural areas. Population density is higher in the south of Poland and is concentrated mainly between the cities of Wrocław and Kraków. The topographical diversity is latitudinal, with the coast and lowlands in the north, followed by a belt of hills and mountains. Mineral resources are in the south. The longest rivers are the Vistula, Odra, Warta and Bug with a meridional course.

Results

Chorems are tools for the structural and iconic representation of complex geospatial situations.

The chorem shown in Figure 6 represents the synthesised state of Poland's development, indicating choremic functions such as specialised, gradient, closure, tropism, surface, trend surface, dissymmetry and gravitation (compare with Table 1).

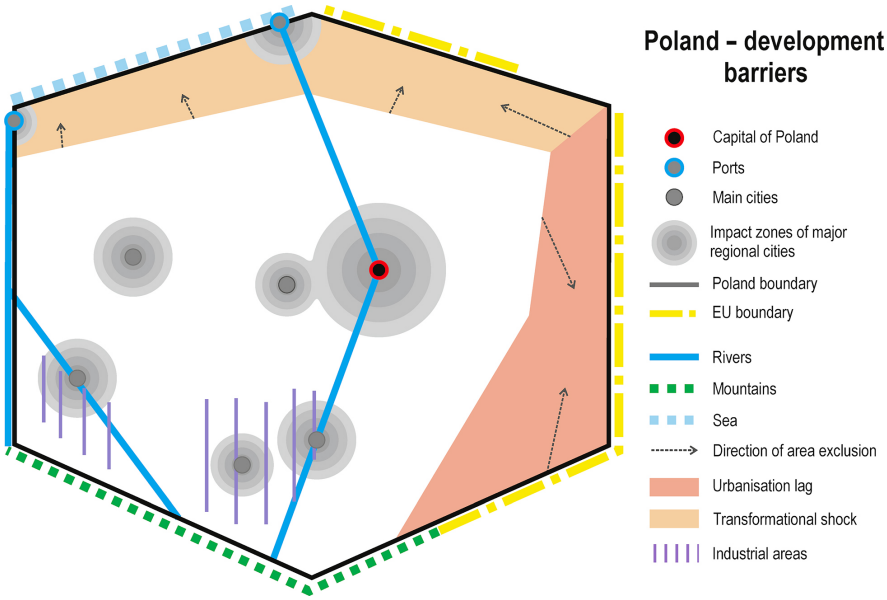


Fig. 6. Development of regions in Poland.

Poland's borders are generalised to a hexagon. The yellow, dashed line denotes the external border of the EU and the Schengen area. This line is a line of constraints and barriers (tropism) in socio-economic development. The green dashed line underlines mountains (Sudetes and Carpathians) as environmental tropism. Closure constitutes black lines (country border), while blue dash lines indicate water bodies (the Baltic Sea) as another type of tropism. Specialised and gradient represent major cities in Poland – their functions and influence on the other parts of the country.

Dissymmetry represents the northern and eastern periphery, where urbanisation lag and transformation shock are observed. The importance of individual barriers and the direction of their growth were applied to the surface and trend surface. Well-developed industrial regions are marked with vertical hatching, which also indicates the natural resources (e.g. hard coal, copper, lignite, sulphur) location. The Warsaw metropolitan area is an example of a gravity model that portrays it as a central node in the transport network and as a basis for the structural regionalisation of Poland.

Poland's development scene can be divided into a latitudinal and a longitudinal direction: the longitudinal one along the border with Belarus and Ukraine, commonly known as the 'Eastern Wall', and the latitudinal one in Pomerania, mainly in the areas of the former state farms (pol. PGR - State Agricultural Farm). The layout of the well-developed industrial areas is latitudinal and refers to the processes that has shaped the Polish landscape, such as glaciation and orogenesis.

Discussion

Academics emphasise that chorems, by focusing on the internal structure of space, patterns, and relationships, provide a tool for users to explore and holistically understand the area (Laurini et al. 2007, Reimer 2010). The main methodological assumptions of chorems are selection, simplification and amalgamation. Dhieb (2020) points out that searching 'for a basic shape by focusing on the outlines of the overall form' is of paramount importance because it allows to skip the elements and structures that are considered as secondary and distracting the user's mind. This provides for using regular shapes and structures. We followed these rules, except for leaving Poland's irregular shape. Despite over 40 years of interest in the chorems, no uniform classification has yet been developed.

Chorems published in the literature are distinguished according to different criteria. Grzegorczyk (2010) took scale, understood as the size of the area presented, into account and writes about global, national and local chorems. Based on the principles of genesis, the context of use and communication, Reimer (2010) classified choremtic maps into seven types: geopolitical, propaganda, mass-media, schematic, mental, geodesign and educational (croquis). The chorem created by this research is a national choremtic map; however, it is difficult to attribute it to any of the chorem types identified by Reimer (2010).

Chorem makers often named the map functions differently. Grzegorczyk (2010) presented the people migration in Burkina Faso as dissymmetry, while Cherni (2015) as tropism. Reimer (2010) cited (after Schmidt-Seiwert 2006) the Mega classification map of European metropolitan regions and their competitiveness. Although the map is not called a chorem, the essence of its content refers to the 'blue banana' map by showing the metropolitan areas with the greatest scientific and research potential in Europe in the form of a pentagon. Dhieb (2020) highlighted the inner structure of the Kingdom of Saudi Arabia representing main cities, (urban poles and nodes), lines linking poles (major axis) and areas of geographical regions. The chorem entitled the development of regions in Poland (Fig. 6) shows the main cities rather as nodes apart from Warsaw, which is labelled as the centre of gravity.

Interestingly, Dhieb (2020) introduced the term 'choremised' understood as a synthesised, simplified and generalised geographical element for the chorems. De Chiara et al. (2011) introduced the concept of a chorem element (a basic graphical structure representing a single real-world object), a chorem as a collection of chorem elements and a chorem map defined as 'set of chorems schematised data of interest related to a specific place or region associated accompanied by a legend explaining the meaning of chorems'. According to the authors (De Chiara et al. 2011), such a classification emphasises the

relationship between a single chorem instance and a geographic object of the real world.

Nowadays, various concepts of dividing Poland into less and more developed parts are adopted. The most classic concepts involve dividing the Vistula line or the S7 expressway Gdańsk-Chyżne (Bartosiewicz, Stańczyk 2014). The agricultural sector in Poland accounts for only a few percentage of value-added, so where it predominates, the socio-economic situation is weaker. The authors also find that the impact of EU cohesion policy on entrepreneurship and GDP (Gross Domestic Product) growth in the eastern regions (Poland B) has not been as positive as in other regions. This view is shared by Bański et al. (2010) and Czerny et al. (2016). The chorem developed in this study highlights the weaker development of regions along the Schengen area. Furthermore, the poor socio-economic growth of regions located in Western Pomerania was emphasised, which was also noted in the land use changes found by Bielecka et al. (2020).

The elaborated chorem allows the reader to quickly become familiar with the nature and spatial location of obstacles to socio-economic development. In this way, this choremetic map raises awareness of selected problems and stimulates further detailed study. The elaborated choremetic diagram contributes not only to cartographers and geographers but also to public administration dealing with SDGs (Sustainable Development Goals), as it is intricately tied to regional development, emphasising the crucial importance of effective land management equitable land distribution and sustainable development. As noted by Bielecka et al. (2022), the differentiation of Poland into eastern and western regions is visible when analysing the indicators of Goal 11 and Target 11.3: Inclusive and sustainable urbanisation.

Conclusions

The map language is one of the most important means of social communication. Chorems are based on their map language; however, as a classic map, chorems translate geospatial data into geographical information through visualisation, albeit in a very generalised and synthesised way. Furthermore, semiotics is one of the pillars of cartographic visualisation, and therefore of chorems. They are always a simplification of reality or rather an author's vision of reality. An important principle in the design choremetic visualisations is the congruence, appropriateness and parallelism between the map and the real world.

Chorem as a simplified, analytical, synthetic model is free of excess content, which often makes classical, complex models unreadable and incomprehensible. On the other hand, oversimplifying the content of a chorem requires a reader to have very good knowledge of the problem and its geographical context.

Today's society often uses icons and emoticons when working with applications and different devices; so, chorems should be intuitive and understandable to them.

Author's Contribution

E.B., A.M., D.D. – conceptualization; E.B., A.M., D.D. – data curation; E.B., A.M., D.D. – formal analysis; E.B., A.M., D.D. – funding acquisition; E.B., D.D. – investigation; E.B., D.D., A.M. – methodology; E.B. – project administration; E.B., A.M., D.D. – resources; A.M. – software; E.B. – supervision; E.B., A.M. – validation; A.M. – visualization; E.B., A.M., D.D. – roles/writing – original draft; A.M., E.B. – writing – review, and editing.

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