NICOLAUS COPERNICUS UNIVERSITY IN TORUŃ

Bulletin of Geography. Socio-economic Series, No. 68 (2025): 7–28
http://doi.org/10.12775/bgss-2025-0011

BULLETIN OF GEOGRAPHY. SOCIO–ECONOMIC SERIES

journal homepages:
https://apcz.umk.pl/BGSS/index
https://www.bulletinofgeography.umk.pl/

City as a system: A systems approach to urban planning and development

Jerzy Parysek[1, CDFMR], **Lidia Mierzejewska**[2, CDFMR]

[1,2]*Adam Mickiewicz University in Poznań,* Faculty of Human Geography and Planning, Poznań, Poland, [1]professor emeritus, [1]e-mail: parys@amu.edu.pl, [1]https://orcid.org/0000-0003-0044-6582; [2]e-mail: lidia.mierzejewska@amu.edu.pl (*corresponding author*), [2]https://orcid.org/0000-0002-9830-2853

How to cite:
Parysek, J. & Mierzejewska, L. (2025). City as a system: A systems approach to urban planning and development. *Bulletin of Geography. Socio-economic Series,* 68(68): 7-28. DOI: http://doi.org/10.12775/bgss-2025-0011

Abstract. The article presents the evolution of a systems approach in socio-economic geography and spatial management from its first application in Polish geography to the times of its gradual use within Complexity Theory. This evolution is accompanied by the transition from the systemic attitude in a cognitive process (geography) to its practical use (spatial management). However, particular emphasis was put on the reconstruction and development of a highly complex functional system which is the city and the use of a systems approach in planning its development. After the general overview of the system as it is understood, the article shows interactional living environment models and a territorial social system. Then, it demonstrates the use of systemic views in relation to the city in the form of urban ecosystem conceptions, a *sustainable city* model, and also an organicist city model, including the *life of the city* as an organicist model of its functioning, and city resilience. The final part deals with the perspectives and determinants brought by Complexity Theory in the realm of cognition and practice. What was also evaluated was the possibility of the application of the systems approach (ideas, conceptions, models) with respect to cognition and practice (urban development and planning) in the current state of science and spatial management in Poland.

Article details:
Received: 26 October 2023
Revised: 29 March 2025
Accepted: 16 April 2025

Key words:
urban studies,
resilient city,
sustainable city,
urban system models & urban planning,
organicist city conception,
Complexity Theories of Cities

Contents:

1. Introduction

Adopted in 2018, a new act on higher education and science (*Note* 1), among its other provisions included a novel classification of scientific disciplines, separating social and economic geography and spatial management as a new scientific discipline. It should be noted at this point that spatial management had been treated as a field of socio-economic geography for many years; nevertheless, because of its interdisciplinary character, it was also a subject of interest for other disciplines. This new discipline investigates spatial differences in the reality we live in, referring to its social and economic features in their relation to natural properties. These differences are studied with respect to various spatial and temporal aspects (chronology and chorology). The investigation into reality within a new discipline has been enriched by practical usage of research results in the process of shaping reality in its material and real dimension, which is called spatial management.

The separation of this new scientific discipline entailed the preparation of this text, which, in relation to the empirical scope of research and practical knowledge use, presents one of cognitively and practically important theoretical and methodological approaches, called a systems approach (or a paradigm). In this case, it refers to a systemic understanding of the city, which is at the same time the basis for knowledge and urban planning. This general objective of the study contains detailed aims. The first is to recall the basic assumptions of *General Systems Theory* in relation to Polish geographical research in which this theory did not find the right place, despite the fact that the subject of research was very often functional wholes. In those wholes, the structures reconstructed were usually generic and static, while systems are highly dynamic. The cited examples of conceptions and models of systems were to indicate great possibilities of the application of the systems approach in various research situations. They also provided an opportunity to present the theoretical and methodological achievements of a leading unit in Poland in this field (*Note* 2). The second specific aim adopted is to present a sequential linking of the cognitive values of the systems approach (socio-economic geography) with its practical use in urban planning (spatial management), which should be a prerequisite for determining a research field of this new discipline and which has long been the case in the centre mentioned. This attitude definitely leads to enhancing professional skills of those practising this discipline. Owing to this fact, the reference has been made to *Complexity Theory* (which has its roots in *General Systems Theory*) the assumptions of which make it possible to dig deeper into the nature of systems, especially into their high level of complexity. This theory is critical of traditionally adopted sustainable development, pointing to bottom-up development tendencies that contribute to urban change in a synergistic way and to self-organisation. *Complexity Theories of Cities*, formulated on the assumptions of *Complexity Theory*, do not only apply specifically to the city which is the subject of this research but also to the city being the subject of activity of various entities and development planning processes (Batty, 2006; Batty & Marshal, 2012; Portugali, 2012b; Portugali & Stolk, 2016). The final, third aim is to determine real possibilities of using a systems approach in planning and spatial management under current legal conditions in Poland. It should be emphasised at this point that this article is neither an overview of the achievements of socio-economic geography regarding the systems approach nor an overview of cities in practical and cognitive spheres.

The connection between the systemic approach of knowledge and practical actions (urban planning) characteristic of this text is an innovative attitude. The need for this type of research is often presented in literature (Betty, 2005, 2009a, 2009b, 2009c, 2009d, 2010; Baynes, 2009; Batty & Marshall, 2012; Crawford, 2016; Moroni & Cozzolino, 2019; Moroni & Chiffi, 2021; Portugali, 2011, 2012a, 2012b, 2023; Portugali & Stolk, 2016). A similar role is played by referring to *Complexity Theories of Cities* in a systems approach, which in Polish geography has not been the case so far.

2. General Systems Theory and its application in geographical research

As has become clear over time, *General Systems Theory* formulated by von Bertalanffy in the 1930s gained in popularity over the next few decades and was recognised as one of the basic paradigms of modern science (Bertalanffy, 1950, 1968); the paradigm which treats subjects of scientific research holistically and functionally. Although in its basic statements living organisms were treated as dynamic, organised wholes called open systems, this theory was adopted soon also in exact sciences, which was facilitated in particular by the possibilities of mathematical modelling of some systems. The application of the systems approach attracted soon representatives of social sciences and in theoretic deliberations also philosophers, including Ingarden (Wołoszyn 1997)(*Note* 3). What is essential to adopt a systems approach in research is a general and universal definition of the system and its properties, which was highlighted by the above-mentioned philosopher.

Every system is a complex, functional whole with its singular, elementary character. In a topological approach, components of each system are elements creating it, which determine its generic structure by scalar relations connecting them. The functionality of the system, on the other hand, results from developed vector relations ($\underline{\mathbf{S}} = \{x_i, R_{ij}, R_{ik}\}$, where: $\underline{S}$ – system; x_i – elements of the system; R_{ij} – internal relations of system $\underline{\mathbf{S}}$, R_{ik} – external relations of the system). Internal relations (R_{ij}) embrace the elements that are part of a specific system (S), and external relations (R_{ik}) link system elements with the surroundings in which it functions ($\underline{\mathbf{E}}$).

Although *General Systems Theory* was formulated in biological sciences, its broad interpretation has led to the development of two theoretical categories of system models: organicist and mechanicist. In the first one, a living organism constitutes a pattern, while in the second – a machine. A difference between both these categories consists primarily in the fact that in the organicist model the relations integrating elements in a functional whole and determining the system structure are deterministic and stochastic, whereas in the mechanistic one, only deterministic. The external relations of the system are also important for its functioning, internal relations are decisive though. The relationship of internal relations to external ones determines the degree of the external opening (closing) of the system. These relations may be active or passive.

A certain reconstruction model of the system structure, but also an example of a practical use of the systems approach, may be the table of input–output (inter-branch) flows proposed by Leontief (*Note* 4)(1966) for the American economy. Treating the economy as a functional whole, he mapped its structure using two matrices: (1) the inputs and outputs ($\underline{\mathbf{X}}_{ij}$) matrix, oftentimes called the input–output (flows) matrix, and (2) the matrix of technical coefficients of production ($\underline{\mathbf{A}}_{ij}$), frequently presented in a matrix form or as tables (Tables 1 and 2). Although the input–output table (Table 1) is composed of three components: vector of total output $\underline{\mathbf{x}}$, input–output (inter-branch) matrix $\underline{\mathbf{X}}_{ij}$, and final output vector $\underline{\mathbf{y}}$, the actual mapping of the structure is matrix $\underline{\mathbf{X}}_{ij}$, whose elements $\underline{\mathbf{x}}_{ij}$ indicate the flow from the *ith* to *jth* economic sector. The rows in the matrix are streams of flows called inputs, while columns are flows which are outputs. The strength of input–output relations in the economic system is depicted, however, by a table of technical coefficients of production (Table 2). The elements of this table are coefficients a_{ij} calculated by the formula $a_{ij} = x_{ij}/x_j$, on the basis of the state of the economy in a specific period of time. The variability of these coefficients makes it possible to calculate

Table 1. Matrix of relations in the economic system input–output (by Leontief) (matrix X_{ij})

Sectors of economy	Global product (x_i)	Inter-sector flows 1, 2, . . . , m	Final product (y_i)
1	x_1	$x_{11}, x_{12}, . . . , x_{1m}$	y_1
2	x_2	$x_{21}, x_{22}, . . . , x_{2m}$	y_2
.	.		.
m	x_m	$x_{m1}, x_{m2}, . . . , x_{mm}$	y_m

Source: own compilation

Table 2. Matrix of technical coefficients of production (matrix A_{ij})

Sectors of economy	Technical coefficients of production (sectors of economy)
	1 2, . . . , m
1	d_{11}, d_{12}, . . . , d_{1m}
2	d_{21}, d_{22}, . . . , d_{2m}
.	
m	d_{m1}, d_{m2}, . . . , d_{mm}

Source: own compilation

them for different periods and use the observed changes for producing forecast. Leontief's idea used for determining the structure and balancing of an economic system can be applied, after appropriate adaptation, to describe the structures of probably each of the systems studied, also the system of the city (*Note* 5). The problem lies mainly in the choice of the elements of the system and relations, which laid out on these elements, map its structure. This requires, however, a tailor-made approach, according to the research problem formulated (Leontief, 1966; Chojnicki, 1971, 1974; Kim, 1989; Dietzenbacher & Lahr, 2004).

Although systems of scientific interest are units separated from the environment in which they operate, they may still create hierarchical patterns in some situations. There are many different systems around, which vary in size, have different types, character, a development degree, function, a level of the relationship with the surroundings, and which also have a different place in the hierarchical system they are elements of. Geographical research investigates many such systems. They can also be found in the activities of spatial management, including planning.

Over the course of time, new general and more specific conceptions and systems models, including cities, have been presented in geography, also in Polish geography, and in other scientific disciplines. Below are shown such examples that are part of the achievement in the area of the application of the systems approach at the geographical unit of the Adam Mickiewicz University in Poznań.

2.1. Interaction human–environment model

The origins of the systemic approach in Polish geography go back to 1971, when Zbyszko Chojnicki published his work on a systemic, interaction model of mutual dependencies between the socio-economic system and the natural environment. The idea of this model sprang from Leontief's input–output model described earlier. The proposed model enriched the economic sphere, which was the subject of Leontief's interest, with a social sphere and environmental one. In this model interaction concerns two subsystems, i.e., socio-economic (human) and environmental (Table 3). It distinguishes four interaction matrices. Matrix A – maps the structure of a socio-economic subsystem, matrix D – the structure of an environmental subsystem, matrix B – interactions of both those subsystems, specifically the inputs of a socio-economic subsystem to an environmental one, and matrix C – also interactions of subsystems, specifically the inputs of an environmental subsystem to a socio-economic one. The relations written in matrices B and C are significant for the

Table 3. The interactive model of the nature–human system

Subsystems	Natural subsystem	Socio-economic subsystem
Natural subsystem	A	B
Socio-economic subsystem	C	D

Source: Chojnicki, 1971; Parysek, 2006

implementation of everything that falls within the concept of rational use of natural environment resources and environmental policy. In turn, the entire model reconstructs the functional structure in the environmental systems we live in, from a local to global scale (*Note* 6). This model was subsequently used to formulate the assumptions of the urban spatial system (Chojnicki, 1974).

2.2. Model of a human living environment

The Chojnicki conception of 1971 was the basis for the formulation of other models of interaction systems in which humans live and operate. Therefore, in 1986 what was devised and presented in the Poznań milieu was a different, relatively simple, systemic model of the human living environment (Fig. 1), and in 1979 its expanded (Fig. 2) version (Parysek, 1985, 1997, 2006).

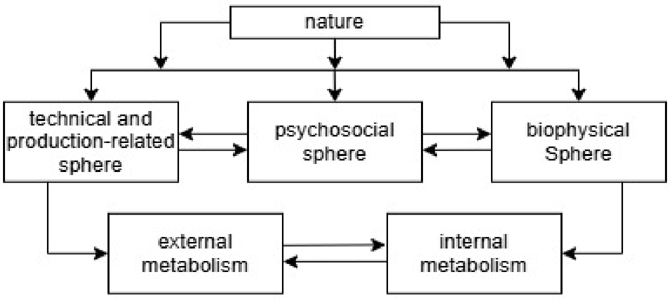

Fig. 1. Simple, systemic interaction model of the human living environment
Source: Parysek, 1985, 2006

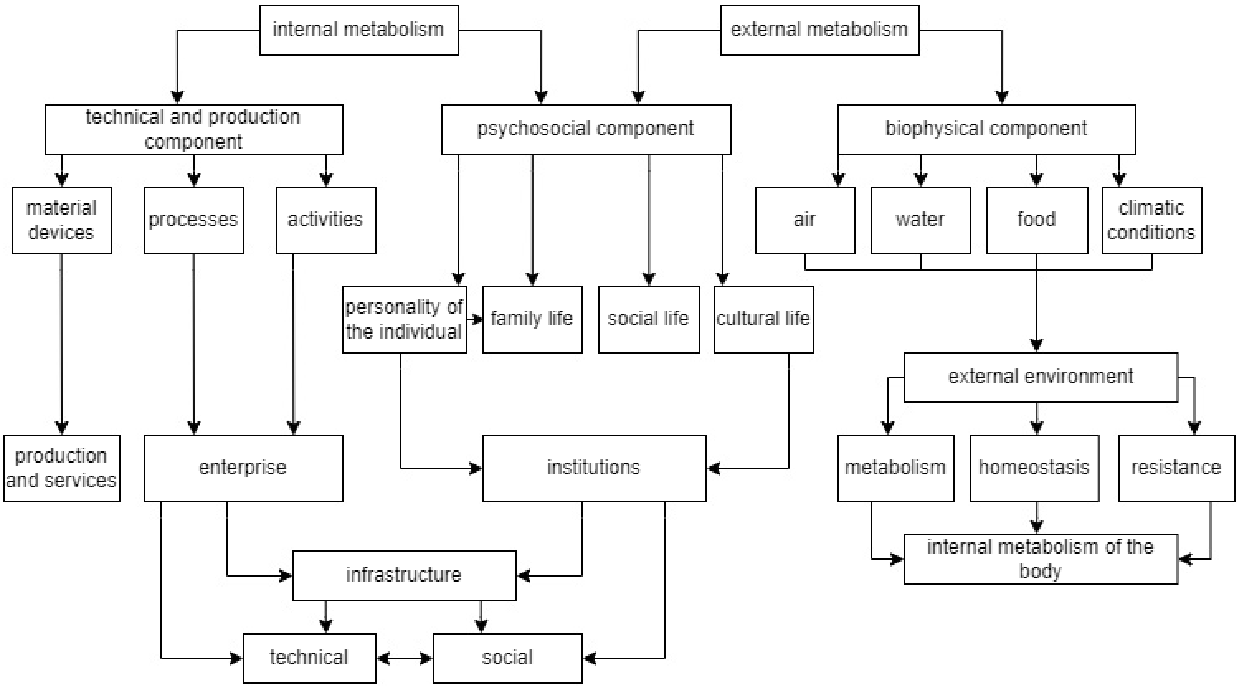

Fig. 2. A developed, systemic interactive model of the human living environment
Source: Parysek, 1985, 1997

The general idea of these models was to separate three spheres of human living, treated as the subsystems of the living environment system in which people operate, but in a different character in each subsystem. The following spheres (subsystems) were distinguished: (1) biophysical, (2) psychosocial, and (3) technical-production. A human being functions as an organism (homo biologicus) in the first one, in the second as a person who understands, feels and thinks (homo psychologicus), and in the third as a person operating in material and immaterial spheres (homo oeconomicus). These spheres are connected by two types of relations, called metabolisms. The biophysical and psychosocial spheres are linked by internal metabolism relations, and psychosocial and technical-production—by external metabolism relations. The surroundings for the system understood in this way are the natural environment represented by atmosphere, hydrosphere, lithosphere and biosphere. The distinguished subsystems of the human environment system thus described are linked with the surroundings by external metabolism relations (Parysek, 1986, 2006; Fig. 1). In the developed model of the system defined in this way, what was distinguished were components of each of the subsystems (spheres) and relations between them were indicated (Parysek, 1997; Fig. 2). These models were created as the basis for describing the subject of local and spatial management, which was taken as a broadly understood human living environment, according to the anthropocentric approach to the development of socio-economic and spatial management (Parysek, 1997, 2006; Dutkowski, 2021; Mierzejewska, 2022). Of course, the city, although specific, is such a human living environment.

2.3. Territorial social system

In the mid-1980s, Chojnicki formulated the conception of a territorial social system (Chojnicki, 1988, 1989, 1996, 2011). As it turned out soon, it could be applied not only in socio-economic geography, but also in broadly understood spatial management (Parysek, 1997, 2006, 2019a, 2019b). Such systems (in fact, the country's territorial division units), are not only a geographical research subject, but pursuant to Poland's applicable law (Act on planning and spatial development), they are also subjects of spatial management. This is so because the administrative bodies of these units are decision-making actors within spatial management (*Note* 7).

A territorial social system, according to Chojnicki is such a social system "in which a collective of people permanently occupies, develops and controls a delimited area of the earth's surface, which is a territory" (Chojnicki, 1988, 1996). This definition shows clearly a holistic and spatial character of social systems, which is emphasised by the fact that the boundaries of territorial social systems are delimited by the boundaries of a country's territorial division units. Understanding territoriality is important for the conceptions of territorial social systems. An occupied area can be only recognised as a territory only when it is inhabited by people with strong, internal social ties, speaking the same language, upholding the same tradition, identifying with the area (which is proved by emotional relationships) over which a particular authority is established (Chojnicki, 1988, 1989, 1996; Parysek, 1997, 2006). When each of a country's territorial division units is a territorial system then also each city is such a system (regardless of its location, size, functions, and so on).

As any system, a territorial social system, is a functional whole, made up by components, relations between them and relationships with the surrounding environment. Chojnicki, in the presented conception, distinguishes two basic, and at the same time complex, system components, i.e., (1) a social layer composed of people (elementary components) and the main fields of their activity, and (2) a material base layer, which is a specific area with its material content (natural and artificial). These components can be recognised as subsystems, made of elements with a lower or higher complexity level. In a geographical (spatial) sense, the material base overlaps the social layer. A specific area is therefore a place where those two components (subsystems) of the territorial social system integrate (Chojnicki, 1988, 1989, 1996; Parysek, 2006). When assuming that the subject of geographic research or planning activities (spatial management) is any territorial social system, it is important to consider its three specific features, i.e., location, boundaries and 'territoriality', which show a certain interdependence (*Note* 8). This is particularly important for spatial management and its component, which is planning. It is precisely the boundaries and authority that constitute a certain autonomy of a specific territorial system, also a city (*Note* 9).

3. A systems approach to planning the development of a city

As has already been mentioned, the subject discussed here is cities treated as systems. Although Brian Berry (1964) has been admittedly recognised as the pioneer in the application of the systems approach in geography, both in the city and the urban system, still, a strictly systems approach to city research was proposed by Funck and Blum (1987) (*Note* 10). In the system of the city, these authors distinguished its three complex elements (subsystems), i.e. (1) urban population, (2) private and public capital resources, and (3) natural resources of the city. The city–system thus defined was an element of a greater metasystem, embracing other cities and the rural areas of a given territory (the surrounding environment). What was typical of the metasystem determined in this way were mainly structures: technological, institutional and behavioural, while the relations between the system of the city and its environment (the metasystem that also includes a given city) embraced primarily economic, socio-cultural, political and administrative processes. The output of the functioning of the relations mentioned were the factors of: production, the quality of the urban environment as well as political and institutional capacity, important for the system operation as a whole (Funck & Blum, 1987). In fact, since then, many researchers have treated the city as a functional, spatial whole, adapting the systems approach (also those mentioned earlier) to various conceptualisations of the city.

3.1. City as an ecosystem

Different urban systems approaches include those in which the city is treated as an ecosystem. In this case, analogously to phenomena occurring in the natural environment, attempts are made to describe functioning of urban units and city residents (*Note* 11). The issue remains, however, whether and to what extent treating the city as an ecosystem provides a new perception of the natural environment, organisation, structure, functioning of the city, and also planning its development. To be called an ecosystem, a given system must fulfil certain conditions that primarily include a mutual inseparable relationship and the interaction of living organisms and the non-living environment. No living organism can live separately, i.e., without the environment. In the environment system (ecosystem), there must be energy flow leading to (1) the formation of a precisely determined trophic structure (food chains), (2) biotic differences (autotrophic and heterotrophic components), and (3) the matter circulation (Odum, 1982). However, it is only possible to discuss ecosystem when basic environment components exist and act collectively, achieving even short-term functional stability (Macias, 2008; Mierzejewska, 2009).

Many authors present an opinion that the city is an ecological pattern (ecosystem), however formed and completely dominated by people whose activity has a profound effect on the its biotic and abiotic spheres. The city is certainly a living environment of residents (individuals) who occupy a special position in this ecosystem—they are the driving force behind change. In such an ecosystem, the matter circulation is specific, still energy flows often in a different way compared to natural ecosystems (*Note* 12). This opinion is not fully endorsed by some ecologists (*Note* 13). Many researchers, however, have no doubt that the city is a whole structural-functional pattern, composed of biotic and abiotic elements of the environment in which processes of the matter circulation and energy flows also occur, therefore it is an ecosystem.

Town planners present an interesting viewpoint. The renown urban designer Jane Jacobs suggests that city buildings, streets, housing estates etc., function as a dynamic organism, changing in response to human operations. She was also of the opinion that these very elements of the city cooperate (synergistically), analogous to natural ecosystems. Thus, she changed relations and processes occurring in natural ecosystems into socio-economic aspects of city functioning, and this is what differentiates Jacobs' point of view from the position of environmentalists and ecologists. Such a perception of the city (ecosystem) made it possible for town planners and architects to discern that the urban spatial development method affects the functioning of the whole city system and may be conducive to its better efficiency. The efficiency which translates into better conditions and the quality of life as well as the level of service provided to inhabitants (Jacobs, 1961) (*Note* 14).

A similar view to the one presented is shared by supporters of so-called architectural ecosystems (Mierzejewska, 2009 after Birkeland, 2004), created by anthropogenic (architecture) and natural elements. The systemic nature of this approach means that what is distinguished are new, symbiotic patterns with properties exceeding a simple sum of the features of individual components of the system. What is important for such systems is effective integration of buildings and the environment into the urban landscape. In thus developed spatio-functional city structures, housing complexes will blend in with the natural environment, tourist sites will be adjacent to forests and lakes, whereas parks and gardens will remain ecosystems with their specific diversity and composition. On the other hand, public facilities will serve as the examples of so-called bioarchitecture with cultural assets. The introduction of architectural ecosystems, however, requires the adoption of new solutions in designing, organisational and financial spheres. The advantage of this conception is that it makes it possible to better understand the organisation, structure and functioning of the city as an ecosystem. It also allows determining the degree to which human activity may affect the formation of spatial urban structure and its effective functioning. The perception of the city as an ecosystem seems to be especially important in a situation when the urban development rate is faster than other processes occurring in a human environment. This is so, because then natural elements are replaced with anthropogenic ones and that would be in a situation in which the city is to be a people-friendly environment formed consciously and purposefully. Cities are gradually losing their natural assets, thus losing their biodiversity, which generally deteriorates the city environment quality, leading to various kinds of problems regarding health and life (Simonienko et al., 2024). This point of view is worth considering while building city models of the not so distant future (Zimny, 1990; Macias, 2008; Mierzejewska, 2008, 2017; Parysek, 2006, 2015).

3.2. Sustainable city

Undoubtedly, a systems approach to the city has high utility when analysing and explaining the phenomena and processes observed in today's world as well as in development planning, especially sustainable, building the city's resilience to threats and stressors, and also forming its functional internal structure.

What is important in sustainable development planning is taking into account relations occurring between economic growth, concern for the environment (mainly natural), and meeting various types of human needs affecting significantly the quality of life (Petrisor & Petrisor 2013; Mierzejewska, 2017). The analysis of these relations may be performed using Leontief's input–output table, which is the basis for the model of the interactive human–nature system and the conception of a territorial social system, albeit with some modification. The basic elements of the territorial social system of a city include, as has already been mentioned, a social layer, which is the collective of people with their needs, pursuits and life aspirations, and a material base layer with all natural and artificial elements, separated in the form of territory. The components mentioned are not simple, but have a high degree of complexity and numerous internal dependencies. They can be treated then as three relatively autonomous systems, being at the same time the subsystems of the city's territorial system. Therefore, one can distinguish the city's social, natural and economic subsystem. While assuming that urban sustainable development means achieving a certain level of balance in the system, putting this conception into practice involves the formation of appropriate relations in the system. One can distinguish three types of relations here (Mierzejewska, 2017; Table 4):

1. relations occurring within particular (sub) systems (social, economic and natural), i.e., intra-system relations, presented in Table x as x_{11}, x_{22} and x_{33} (the main diagonal of the matrix) deciding about the possibility of achieving intra-system equilibria;
2. relations between particular subsystems (between a social and economic subsystem, social and natural as well as economic and natural), therefore intersystem relations, described as x_{12}, x_{13}, x_{21}, x_{23}, x_{31}, x_{32}, deciding

Table 4. Model of relations holding in an urban system

Aspects		Human community	Territory	
			natural environment (nature)	artificial elements (economy)
Human community		x_{11}	x_{12}	x_{13}
Territory	natural environment (nature)	x_{21}	x_{22}	x_{23}
	artificial elements (economy)	x_{31}	x_{32}	x_{33}

Source: own compilation on the basis of Chojnicki (1989)

about the possibility of forming intersystem equilibria, and
3. relations with the environment, making it possible to achieve equilibrium within the agglomeration system.

The complexity of the city's system does not mean that all its components are equally important. The most significant role is played by people because it is them who decide about the creation, management and maintenance of all the other elements, which refers to the conception of a territorial social system (Mierzejewska et al., 2020). It is a human being generating various types of activities: economic, cultural and political that plays a causative role in forming all those relations, and thus in determining the method, efficiency and stability (equilibrium) of the operation of the whole system (Chojnicki, 1989, 1999). A key role in this respect is played by a decision - making process, covering political aspects, which results from the knowledge of laws, rules and mechanism governing the subsystems: social, economic and natural as well as relation occuring between them (Mierzejewska, 2017).

3.2.1. Conception of urban substructures

One of the important features of systems is that they may create hierarchical patterns. Therefore, the city may be part of a better organised urban system (e.g. agglomeration, metropolitan area, the settlement system of a region, country, etc.), but it is a system itself (a territorial one) composed of subordinate systems, which has been already pointed out. In this context it may be assumed that sustainable development of a city as a whole may be determined by the way its component parts are spatially organised, how they develop and function. This viewpoint underlies the conception of urban substructures understood as relatively autonomous wholes operating in the city's spatio-functional structure, comprising the urban subcentre (core) and the area of its influence (an area defined by the walking distance to the subcentre), with a high degree of coherence, distinguished basically by spatial relations generated by the residents living in a given area. It is these relations that determine the coherence mentioned and a relatively autonomous nature of such a structure within a city, making it possible to treat substructures as the spatial subsystems of the city's territorial system (Mierzejewska, 2017, 2020). The subcentres of substructures should be densely populated, intensively developed, multifunctional, ought to ensure that residents' basic needs are met and also provide access to public space (including urban greenery) for inhabitants and should be integrated into an efficient public transport system ensuring the functionality of the city system as a whole. An urban substructure may be also perceived as a relatively self-sufficient, separate spatial system that consists of many interrelated elements (inhabitants, business entities and so on), operating within the system of the city with which, as an environment, it has many relations (Mierzejewska, 2020). One may assume that the proper distribution of urban subcentres with a high population density and the cumulation of central goods and services may better and more effectively fulfil the residents' needs while generating a sufficiently large demand for these goods and services to make it possible for the entities offering them to develop in the market economy. Such a city internal structure is undoubtedly polycentric. It has the advantage of providing residents with fairly equal, egalitarian and easy access to goods and services offered by the city while maintaining a high quality of the natural environment, economic efficiency and shaping the conditions for building the communities that identify with the area they live in (Mierzejewska, 2021). Thus, the urban structure based on substructures incorporates the principles of sustainable development and is conducive to building city resilience.

3.3. An organicist conception of the city

The adoption of a systemic, organicist model of the organisation, structure and functioning of the city may suggest treating this settlement unit as a sort of living organism, in full awareness of the human-made nature of the city itself (*Note* 15). Analogies between a city and an organism have been sought by many other researchers pointing out similarities in the processes taking place in a city and in a living organism (Haken, 1993). It seems, however, that treating city like an organism is perfectly justified. The city, being a complex and functional whole (a system), has got all the features (necessary conditions) a living organism needs to have (fulfil) (Gánti, 1986). Gánti distinguishes five necessary and three potential features (conditions) that an object must possess to be recognised as an organism (also as a living system) (Tables 5, 6). The necessary features define mainly a living organism, whereas potential ones refer more to life processes (Kunicki–Goldfinger, 1978; Horst, 1976; Gánti, 1986). Both are important when we intend to treat the city as an organism, i.e., a living system. Some identification in the city seems to be possible concerning potential

Table 5. The city and a living organism: basic analogies

Living organism	City
circulatory system (blood circulation)	road infrastructure, street traffic, transport
nourishment	supplies of energy and matter (goods and services)
digestion	consumption (making use of energy and matter)
metabolism	production, service provision (processing of material to provide energy and synthesise new material)
nervous system	information flow
brain	management, knowledge, technology
senses	reception of information, perception
excretion	waste production and storage (processing)

Source: own compilation

Table 6. The city as an object meeting the necessary conditions for a living organism

Necessary conditions with reference to living organism	Necessary conditions with reference to city
unitary whole, or entity instinct from its surroundings	A city is a settlement unit distinct from its surroundings, although today the boundary tends to get blurred; it is also a distinct self-governing unit in a country's territorial division, hence it is a unitary whole.
metabolism	There is a transformation of matter and energy in the city area; metabolism can be narrowed down to supplying financial components of the urban system that guarantees its operation and development.
homeostasis or maintaining internal equilibrium	Homeostasis is a state of functional equilibrium of the urban system determined by the operation of urban services.
subsystem of information storage and processing, important for functioning	Urban services must accumulate, store, process and use all kinds of information in order to be able to steer the city's operation and coordinate its development.
internal operation – regulating system	This system is composed of city authorities and their agencies managing the city's operation and development using legal, administrative, economic-financial, organisational-technical and other means.

Source: own compilation

features of an organism documenting its life processes, which is presented in detail in Tables 5, 6 and 7. Despite the fact the city sprawls outwards and intensive development is not always fully compatible with administrative boundaries, the city is still of both singular and holistic nature. The city, as every living organism, undergoes metabolism and energy transformation, albeit of specific character. To function properly, the city must demonstrate equilibrium between its constituent elements. The state of its undisturbed functioning and balancing its structures may be then identified with homeostasis which is guaranteed by metabolic processes (for the city also operation of municipal services). This is not always the case, however. What often emerges are unpredictable various phenomena and processes (natural, social, economic, political, military, epidemiological, catastrophic, etc.) to which the city should respond properly to secure its survival and development. On the other hand, the possibilities of urban development may be identified with organism reproduction, structural and functional transformations may be recognised as evolution, whereas the fall of the city as its demise (*Note* 16). The city is, undoubtedly, a teleological system. It operates to ensure the best possible living and service conditions for residents. Simultaneously, this is a system where causative elements behind its functioning and development are the very urban dwellers. This situation means that this kind of system requires the organisation and functioning of a relevant regulatory subsystem, which is a municipal authority, and specifically its local government. One of the fundamental tasks of authorities is efficient city governance and effective planning its development.

The reference to organism features allows treating the city not only as a specific body, but also as a living and vital organism (Parysek, 2014, 2015; Parysek & Mierzejewska, 2013, 2014).

3.3.1. The city and its life

Commonly used and essentially biological, the term ‘life’ is understood in various ways. It is usually defined as a set of vital processes occurring in living organisms which undergo metabolism and energy transformation with its environment, and also homeostasis, which is the ability to maintain the state of certain internal equilibrium (Kunicki–Goldfinger, 1978; Horst, 1976; Gánti, 1986). Other definitions treat life as a property of organisms in which life processes occur. A significant feature of life that stems from the nature of metabolic processes is the

Table 7. The city as a system satisfying potential conditions of a living

ability to grow and reproduce	The city has no ability to 'reproduce', but it can develop and grow; the growth concerns both, its broadly understood size and its economic potential, and has a quantitative and qualitative aspect. The city can be said to 'reproduce' if this process is taken to embrace the appearance of new quarters, housing estates or investment areas. The use of the term 'growth' is more justified than that of 'reproduction'.
variability in replication, or evolution	One can speak of the evolution of a city, although this is different from the evolution discussed in biology (the evolution of species). The evolution of a city generally means the transformation and adjustment of its spatial organisation and economic system to current civilisational-cultural reality. While some spatial forms of the city can endure longer, their character evolves over time to meet the challenges of new times and the changing urban community.
mortality (death rate)	The greatest problem in an identification with the city is posed by what in living organisms is called mortality (or better, dying). What can be taken as 'mortality' in the case of cities is certainly their downfall. Another kind is their demise or serious destruction caused by a disaster or war, and a decline brought upon by an economic crisis. The manifestation of the city’s slow death is also urban shrinkage. While 'the death of cities' is not a widespread process today, the fall of cities recorded in history can be taken as proof of their still possible 'mortality'.

Source: own compilation

ability of living organisms to maintain a higher level of organisation, that is a lower entropy than their surroundings, which comes at the expense of energy consumption. Living functions of organisms manifest themselves also in the ability to reproduce and inherit traits (Horst, 1976; Gánti, 1986).

Most processes and life phenomena reoccur. This typical feature makes it possible to optimise regulatory processes in the system and their synchronisation with the external environment. Thus, many vital functions change their intensity periodically. It is also the purpose of biology that life processes do not interfere with other, important organism functions. All that dictate the need to synchronise organism activities, mainly in time. With reference to a human organism, the lack of such synchronisation would cause problems with social life (it would complicate life); it would impede reproduction, childcare, work, etc. (Sadowski & Chmurzyński, 1989). These problems are prevented by rhythms of biological phenomena, inherent in the functioning of an organism. This rhythm subordinates changes in the organism to periodic changes in the environment in which this organism functions. This relates to the sense of time and its recognition, which is manifested by certain rhythm (e.g. eating, but mainly wakefulness and sleep). Biological rhythm may be recognised then as the demonstration of organism adaptation to the rhythm of occurrences in the environment. The main role in this regard is played by adjusting to the day-night cycle and to the periodicity of the seasons. For humans, the periods of wakefulness and sleep are regulated by times of day, but also by requirements of a social and occupational life, lifestyle and established habits. It is also regulated by the clock, but not so much biological but mechanical or electronic, keeping time devoted to various purposes.

As a characteristic feature of the city (treated as an organism) is also the rhythmicity of the elements making up this territorial system, what seems reasonable is adopting the term 'life' also to the city. While we can identify many various rhythms in its life, however, they are all, to a greater or lesser extent, a consequence of the Earth's rotational movement. They also result from the properties of the city as a system composed of three distinct subsystems: natural, social and economic. The rhythmicity of nature is of a different kind than that of city residents and the structures they build, and they both differ from the rhythmicity of the city's infrastructure, economy or services. Those various kinds of rhythmicity of nature and human behaviour patterns, social structures, urban infrastructure and services, economic entities, etc. make up this complex process that can be called the city's life. Taking into consideration how the components of the city system work in time, one can distinguish certain characteristic rhythms of operation and assign to them specific domains of city life. One can certainly speak of: (1) daily (daytime activity), (2) 24-hour, (3) weekly, (4) monthly, (5) yearly, and (6) multi-year rhythms presented and described in Table 8.

Table 8. The city's operating rhythms

Rhythm	Entities operating in a given rhythm
Round-the-clock	economic entities working round the clock, municipal utilities (power, gas, heat, water and sewage systems, communications, public transport, etc.), health service, life and property security units (ambulance service, hospital emergency wards, fire brigades, police), some retail establishments (24-h shops, petrol stations) and services (emergency road service)
Daily	individuals, households, economic entities, offices, kindergartens, schools of various types, health-care facilities, most retail establishments, service facilities, units offering municipal services, recreational facilities, etc.
Weekly	most working places, kindergartens, schools, universities, cultural establishments, medical establishments, sports facilities (events), churches, etc.
Monthly	economic entities, recreation centres
Yearly	economic entities, budgetary units, including schools of various types, churches, cultural institutions, sports and tourist institutions
Random	cultural and sporting events, meetings, conferences, congresses, etc.

Source: own compilation

Although several categories of city-life rhythms have been distinguished, the generator of all of them is man, his day-and-night activity and his needs that have to be satisfied (*Note* 17). Thus, the primary role in shaping the life of a city is played by its residents, but in the age of high dynamics and an increase in the degree of centrality of some cities, its life is also substantially modified by residents of the suburban zone and visitors (*Note* 18). The functioning of urban infrastructure should be adjusted then, and it often happens so, to city-dwellers' needs. This means that the functioning of economic entities, public services, offices and other elements of urban structure should change in time accordingly (Mierzejewska & Parysek, 2014; Parysek, 2014, 2015; Parysek & Mierzejewska, 2013, 2014, 2016).

Distinguishing some of the rhythms in the life of a city presented in Table 8 is natural because it is connected with the operation of single individuals, families, households, economic entities, public services, offices, etc. Other rhythms underlie human life cycles, and still other involve conventionally understood concept of rhythm (e.g., dance rhythm, musical rhythm; Lefebre, 2004). The proposed model of the organicist understanding of the city and its life was applied in the research on the urban system of Poznań (Parysek & Mierzejewska, 2013, 2014).

3.3.2. Resilient city

The adoption of an organicist conception of the city makes it possible to relate various features of a living organism to phenomena and processes occurring in the city. Apart from such features as 'metabolism', 'tissue', 'heart', or the above-mentioned 'life', what is increasingly often referred to the city is 'resilience', also characteristic of living organisms. In its most basic notion, resilience means the ability of a specific system to effectively respond to external or internal disturbances and a positive adaptation to changing conditions (Timmerman, 1981; Alwang et al., 2001).

As the notion 'resilience' applies equally to all systems the systems approach is also adopted in research on city resilience in which cities are seen, among others, as ecosystems, adaptation systems, but simultaneously as territorial systems (authority extending over a given area, its tasks and competences). As the territorial social system of a city constitutes a subclass of social systems, it is evident the main focus here is on the inhabitants, their activities and relations with the territory they live in. Such treatment of the city is in line with the perspective presented in publications on resilience in which the human being is put at the centre of attention, and the main assessment criterion when measuring urban resilience is minimising adverse impacts on urban dwellers and enabling their rapid return to normal functioning after experiencing disturbances (Desouza & Flanery, 2013; Mierzejewska et al., 2020). These interactions may be analysed with reference to the relations, including feedbacks described in the territorial social system conception (Chojnicki, 1989). These are: (1) relations and social activities (occurring between particular units, collectivities of people and social groups); (2) relations and transformation activities (occurring between people and material objects, and embracing actions aimed at turning the natural environment or material objects into facilities of a utility nature), and (3) relations or natural-ecological interactions (involving the impact of nature on people, and essentially being the coupling pattern human–environment–human; these relations are highly dependent on the character of an economic subsystem and have the global dimension).

In each systems approach, a crucial role is played not only by relations within a given system, but also relations with the environment, creating certain conditions in which the system functions and develops (Parysek, 1997, 2006; Mierzejewska et al., 2020). This is an important issue for research on city resilience and planning activities in this respect, because the origins of crises, risks or threats (stressors) to which cities and their inhabitants are exposed can often be found not in the very city, but in its more immediate or more distant surroundings. Some of them are global, e.g., economic situation, climate change, pandemics, global situation, wars, etc. (Mierzejewska et al., 2020). A multitude of elements i relations (including interactions) in the city system combined with the uncertainty of when, where and with what intensity the risk may occur means that city resilience planning should be considered an extremely difficult task. This is so because it requires a comprehensive, flexible and multifaceted approach to urban development. What is therefore needed to achieve the overall system resilience to disturbances are coordinated measures within its particular elements which make up the resilience of the city system as a whole (Mierzejewska et al., 2020).

The systems approaches presented are very useful for planning urban development. They also pay attention to complexity and dynamic nature of the city as a living organism.

4. From General Systems Theory to Theory of Complexity and Complexity Theories of Cities

As was already mentioned, General Systems Theory was the foundation for creating a new category of notions, conceptions, models and even systems theories. Some culmination of the works undertaken at the end of the 20th century is Theory of Complexity, rooted in the basic assumptions (as its predecessor) of biological sciences. It was shortly adopted and developed, however, by social sciences, including socio-economic geography, mainly in relation to cities (Batty, 2005, 2009a, 2009b; Holland, 2014; Portugali, 2011, Sengupta, 2017). What is more, many of the proposed solutions were formulated, considering their application in urban development and urban planning (Batty, 2009c, Batty & Marshal, 2012; Moroni & Cozzolino, 2019; Moroni & Chiffi, 2021; Portugali, 2012a, 2012b, 2023; Portugali & Stolk, 2016).

The very theory is complicated, because of its interdisciplinary nature, which largely depends on theory and methodology of these disciplines on the one hand and on the applied methods of collecting information and its processing (*Note* 19) on the other. A significant contribution to the development of Complexity Theory was made by the following: thermodynamics, synergetics, theories of game, chaos and bifurcation, social physics, informatics, newer fields of mathematics, fractal analysis, entropy maximisation, agent-based models, cellular automata, network analyses, and so on. Among the information collection techniques one can mention aerial and satellite imagery, remote sensing, smartphones, Internet, social media, various information systems and data banks, big data, artificial intelligence, etc. (Batty, 2005; Baynes, 2009; Banaszak et al., 2015; Nijkamp et al., 2019). This theory, however, is primarily the expansion of General Systems Theory by boosting its assumptions, a deeper insight into the system structure as a whole, into the nature of its elements, taking account of certainties and uncertainties in the functioning of systems, their ability to self-organise and operate safely (Batty, 2009a, 2009d; Cilliers, 2000; Rauws, 2017).

Complexity Theory in relation to social sciences, including cities and urban systems, assumes in the system considered environments of various nature (subsystems, spheres, elements) constituting the urban environment. These environments (natural, biological, social, built-in, market, business, political, etc.) are nothing else but relatively homogenous layers (subsets) grouping elements of the city system. This is, however, always a highly complex system, and its properties are not a simple sum of properties of those environments (components, subsystems, layers). Urban systems vary by a large number of different, often interdependent, but to a great extent autonomous components. Moreover, they are considered adaptive systems (CAS). Adaptiveness means readiness for change, but primarily skilful adaptation to it based on previous experiences (Batty, 2005, 2009b).

In the systems approaches and models presented here, systems are treated alike. Three basic subsets (layers) were always distinguished: natural, social and economic, whose selection and internal diversity emphasised their complexity. The complexity, on the other hand, was strengthened by relations, that is adopted flows between distinguished elements. These, in turn, determined the structure of a specific system. Likewise, in Complexity Theories of Cities, relations were mainly the flows of people, but also goods, money, and information which pointed additionally to the dynamics of systems (Chojnicki, 1971, 1974, 1985,1998, 1999, 2011; Mierzejewska, 2009, 2017; Parysek, 1986, 2006, 2014, 2015; Parysek & Mierzejewska, 2013, 2014).

5. Systems approaches in urban planning and urban development in the Polish legal system

The specificity of the systems approach to investigating cities, the basis of which are the assumptions of Complexity Theories of Cities, is to combine cognitive aspects with practical ones to use this theory for planning the development of such a highly complex system as the city. The literature provides publications whose authors present features of complex adaptive systems that should be taken into account in urban planning, considering cities as such systems. Therefore, it ought to be remembered that cities are self-organising systems, developing in a non-linear way, subjected to sudden and unexpected changes, capable of adaptive behaviour and evolution (the whole and elements) with experience and in relation to path dependence. At the same time, such systems are characterised by unpredictability of behaviour as a result of difficulties with identifying initial conditions, adaptation of the autonomous elements of the system to their environment and emergency. All this, however, must be recognised in conducted research. The important thing is also to remember that every city, although an autonomous spatial unit, occupies its place in the system of cities in which it operates and where it is subjected to the influence of other cities of this system (Batty & Marshal, 2012; Colander & Kupers, 2014; Crawford, 2016, Holland, 2014) (*Note* 20).

The organisation, structure, functioning, development and physical planning of cities have been analysed for many years (Parysek, 2005). Yet, it was the beginning of the 21st century that saw the transition from treating cities as systems of certain equilibrium to aggregated, more evolutionary systems (Prigogine & Stengres, 1984; Prigogine, 1997). For development planning, it means transition from the primary role of type structures (land use) to functional structures, that is those determining flows between land use forms or elements of city development, which can be reduced to the location of housing areas and the achievement of broad objectives. What is more, it is assumed that those structures emerge from the bottom up as a result of various decisions of entities functioning in the city area, pursuing their particular interests in certain places, including community-wide goals (municipal authorities). This new paradigm, constructed on Complexity Theory, appears to be one in which cities are treated as emergent structures, generated by the combination of hierarchical decision levels, arising and bottom-up driven in a decentralised way, which is compatible with the knowledge of complexity. These levels also dominate in the simulation of the form and city function (Batty, 2009a). Changes that currently occur in cities as systems result mainly from individual decisions taken, at the lowest level, by some residents, economic entities, various investors, city authorities, social organisations and other bodies, and in some cases, also regional and national governments. Multistakeholderism of this process means that those changes are usually non-linear, which is not without its impact on the risk associated with the decisions taken and the uncertainty of the situations in which one will have to operate and pursue objectives (Prigogine, 1997; Abbot, 2005, 2009; Alfasi & Portugali, 2007; Albrechts, 2011; Rauws, 2017). Despite this fact, urban systems as wholes, are characterised by their ability to self-organise and adapt to certain behaviour patterns, mostly created in the lowest level of urban structures.

All theoretical and methodological conceptions of the city as a system should find their reference both to research on the reconstruction of the organisation, structure and functioning of the city system and to the question of its development, especially physical planning. Numerous publications on the *complexity of cities* include such references (Batty, 2009c, 2009d, 2010; Baynes, 2009; Batty & Marshal, 2012; Portugali, 2012a, 2012b; Crawford, 2016; Portugali & Stolk, 2016; Moroni & Chiffi, 2021). Their adaptation may be sensible only when the following are considered: the reality in which cities function, a general system model adopted, a target city model and a country's legal system regarding physical planning in particular (urban planning, urban development).

There is no doubt that, at the current level of knowledge, only an organicist system model of the city can be adopted, fitting well into the new systems paradigm. This is so because this model maps a dynamic nature of this settlement unit and its functioning, and also a high level of complexity and dependency. Although the relations will be linked to spatial forms of land use by which these relations will be generated (location of the population, economic entities, new investment, etc), the dynamics of this structure (and not structures of land use, static in their nature), however, will be primarily important for the structure of such a system (Dzięcielski et al., 2021). Into this very model the conception of *life of the city* was included, the conception in which the elements of the system are components of urban infrastructure, i.e. one that creates life and work conditions for city dwellers, therefore a local life environment (*Note* 21). The functioning of such infrastructure should be adapted to residents' activities in time and space, and fulfil their needs in the best possible way (Parysek & Mierzejewska 2013, 2014; Parysek, 2014, 2015). It seems that such a system model of the city and its functioning may also include some ideas, conceptions and models of cities of the future presented in the literature, and there are many (Parysek, 2021) (*Note* 22). Some appear to be interesting, but their implementation is quite a different issue. One may indicate, e.g. such conceptions: *Cities for people* (Gehl, 2009, 2010), *Happy city* (Montgomery, 2015), but it is more a city of happy inhabitants, *The well-tempered city* (Rose, 2019), or *Cities of harmonious development* (Gzell, 2015) (*Note* 23). These conceptions were devised, however, in various countries and their adoption in urban development should be considered in the relevant conditions, mainly legal. This may often raise the question whether it is a real idea for the city of the future or only dreams that will not come true (*Note* 24).

The legal conditions Polish cities operate in determine, however, that a framework system model of the city treated as the subject of urban development and planning must be a territorial social system. The framework system model, that is such encompassing other models, but which imposes restrictions at the same time. In this model, city boundaries are designated by the country's territorial division, with a full awareness of blurred and changing, a real course of boundaries resulting from the understanding of the city as a highly urbanised spatio-functional structure, which is the subject of cognition. Such a highly urbanised area is the city and the suburban zone (at least adjacent to the city boundaries) or its part, and often even the entire agglomeration. One should remember that in a spatial unit such designated (city in administrative boundaries), the local government is in control, which, by Polish law, manages administration, especially urban planning. In practice, any change in the spatial structure of the city so designated results from decisions of local authorities (*Note* 25).

Unfortunately, the law regulating the functioning of urban planning does not acknowledge a systemic nature of the city. The city is not treated as a functional, complex whole, because no general spatial development plans of a city as a whole are prepared, the provisions of which would be mandatory local law. Plans called *local spatial development plans* are devised only for separate sections of the city on the basis of individual preferences and needs. The so-called *study of criteria and directions of development*, the provisions of which should be considered only when preparing local plans and carrying out spatial policy, also do not fulfil the function of a general plan (Parysek, 2009, 2016a, 2016b). Spatial policy remains still in the hands of local authorities (Parysek, 2010). As a result, the city is a mosaic of separate plans, devised for selected areas. There is no systems approach to the city then with respect to urban planning. The city develops bottom-up – there are investors, there is demand for new locations, crisis situations occur which should be resolved and which call for formal decisions of local authorities. Polish law, however, offers the way out of this situation. Investors may apply for *a local spatial development plan* for the area they are interested in (usually in line with the investor's requirements) or they may request that local authorities determine the so-called *development rules and parameters of land use*, making it possible to realise investment in the area indicated by the applicant without complying with the spatial policy adopted and recorded in the study. The reason behind this situation is clearly the lack of a general spatial development plan for the entire city as a complex system. In turn, this results in chaos in physical planning, pathological urban structures and growing vulnerability to various threats. It is worth adding at this point that local spatial development plans are devised by various planning offices, and their selection is made by tender. There are of course urban physical planning offices, but only in large cities. Moreover, their low capacity does not fundamentally affect the increase in plan coverage of the city. They would only contribute to the creation of a mosaic of land use forms, which even with 100% of coverage would not be an urban spatial development plan, understood as a functional, complex whole, being a high-quality life and service environment. It should be also added here that there are no binding legal regulations on socio-economic development, and development policy is carried out based on *development strategies* adopted by municipal authorities, which is primarily a document of socio-economic development policy. Cities, however, do not have to have such documents. The implementation of the possessed strategy is a completely different issue.

6. Conclusion

Although the holistic approach has been used more or less consciously in geographical research for many decades, it is only cognitive values of the *General Systems Theory* that gave rise to the development of a new systems approach to research in various scientific disciplines, including socio-economic geography and spatial management. The systems paradigm, however, was adopted gradually. Some propositions in this regard were presented here, albeit on the example of the scientific achievements of only one geographical unit (*Note* 26). The systems approach has found its place with determining subjects of development planning of local, regional and spatial management, treated as territorial social systems. Unfortunately, strictly systems-based approaches have not been very popular in conducted research, which is evidenced by a relatively small number of publications. The propositions of the systemic treatment of objects have not been adopted in spatial management, especially in planning; legal requirements of the planning system are to be blamed for this state of affairs rather than planners. The lack of general spatial development plans of communes, including cities, excludes the systems approach also in spatial management, especially in planning. What is also not conducive to considering the systemic nature of territorial social systems – objects of spatial management, especially cities – is making the organisation and operation of urban planning services subject to existing regulations. These units do not devise general urban spatial development plans, because such a document does not exist in the legal system. A non-existent control over the implementation of provisions of the approved local plans is a completely different issue, and the implementation of the investment based on the so-called development rules and parameters of land use (*Note* 27) is a total misunderstanding. The truth is that it is investors, especially so-called housing developers, that are the main perpetrators if not of chaos in spatial development then at least its pathology.

A cognitive side of the systems approach does not also have the best conditions for development. The functioning of universities, especially the priority of education and not necessarily the intellectual elites, is not conducive to development of research related to *Complexity Theory*, which requires more staffed teams of highly qualified specialists, proficient in theories, methodology and advanced applicable research techniques (*Note* 28), teams having relevant data banks on the one hand and computing potential on the other. Despite this adverse situation at universities and the overload of scientific and didactic staff with broadly understood didactics, there are still publications related to the realm of Complexity Theory (*Note* 29). In this case, it is difficult to talk about the meeting of science and practice. Without changing the model of the functioning of spatial management in Poland, without relevant legal regulations, municipal authorities will not feel the need to use scientific knowledge in practice, and science will still be focused on theoretical and methodological deliberations which will bring researchers nothing but personal satisfaction. However, even in this case, a new model of science functioning is needed, especially for universities. Still, new does not always mean better. The present model and modest material conditions of science gives an opportunity though, as part of the discipline of social and economic geography and spatial management, to remain within the paradigm of the systems approach of the *complexity* level, and conduct research which makes it possible to better understand the organisation, structure and functioning of such a complex system as the city and better shape its spatial development for the residents. The opportunity lies in the initiative and intellectual potential of some of the existing scientific teams

Notes

1. Act on higher education and science of 18 July 2018.
2. This centre is the former Institute of Socio-Economic Geography and Spatial Management, now the Faculty of Human Geography and Planning at the Adam Mickiewicz University in Poznań, where the research school formed by prof. Zbyszko Chojnicki (called the 'Poznań School of Socio-Economic Geography and Spatial Management') has been still functioning, and in which theoretical and methodological studies within socio-economic geography and spatial management have developed together with the application of quantitative methods and systemic approaches related to the subject of the research conducted.
3. As far as philosophy is concerned, Roman Ingarden wanted to use the assumptions of this theory to define the structural construction of a human being. In the ontological analysis of the idea of a living organism, he used elements of systems theory and, in particular, system terminology, i.e. the notion of system, subsystem, hierarchy of systems or subsystems, etc. (Ingarden, 1987; Wołoszyn, 1997).
4. Nobel Prize winner in the field of economics, one of the founders of econometrics.
5. Leontief's table of flows is a typical interaction matrix and it is used in geographical research in which links are to be the basis for determining different types of structures, e.g., nodal regions, agglomerations, areas of influence of settlement units and also spatial relations, defined on the basis of movement of goods, people, money, technology, information, so-called carbon footprint, etc. (Lin et al., 2017; Lee & Hlee, 2021). It is also used in a classic version of the table of flows to determine a regional structure (Chisari et al., 2012; cf. Chojnicki, 1961).
6. Whenever the term environment is used (without an adjective), it refers to the conglomerate of the natural and socio-economic environment taken together.
7. The development of this conception can be followed in numerous works by Chojnicki (1985, 1988, 1989, 1996, 1999, 2011) and also other authors (Czyż, 1996; Parysek, 1997, 2006).
8. This is particularly important when considering the region as a territorial social system, but less so, when the city is the subject of study.
9. In the case of regions (the country's territorial division units), boundaries and the authority, and specifically its level, determine territorial integration, and thus the creation of a spatial hierarchy of regions.

10. Berry however makes an attempt to combine General Systems Theory with other theories and geographical conceptions referring to the urban system, such as Zipf's Rank Size Rule, Christaller's Central Place Theory (1933) and Lösch's Theory of Economic Region (1956).
11. Terms borrowed from ecology were also often used in economic phenomena, e.g., service and function succession, or competition.
12. It is characteristic that the city often imports its primary sources of energy, i.e. electricity, fuels and food, from outside areas.
13. Some ecologists' contention is that incompleteness of the type composition (elements of the system) makes the city dependent on external energy supplies, which causes breaking the trophic chain and disturbances in energy flows. However, one should consider the fact that elements (the type composition) of the city treated as an ecosystem are not only individuals but also social groups, economic entities, institutions, also populations of animals and plants, between which energy and matter flow, albeit specific.
14. This is a reference to Leontief's tables of technical production coefficients, which measure the strength of the interrelationships and indicate how a change in one element of the system entails changes in the others.
15. Of course, in a systems approach, it is also possible to adopt a mechanistic model, but the nature of the city is such that its development and functioning resembles more that of an organism than that of a mechanism.
16. The process of urban shrinkage currently observed may also be recognised as a symptom of the imminent death of the city, at least in its existing and developed form.
17. Variable in time and space, rhythms of residents' life and the functioning of urban infrastructure were identified on the basis of the rhythmicity of human organisms, which is regulated by the Earth's rotation. At the same time, it was assumed that the functioning of urban infrastructure must be adapted to the rhythmicity of human organisms to the greatest possible extent. The classification of rhythms cited is therefore a consequence of assumptions based on the physiology of the human organism. The rhythm of city functioning is therefore the resultant of both these processes. This is a different approach from the classification of rhythms in which social life takes place or cities function, which we deal with in sociology (e.g. Lefebre, 2004; Crang, 2001).
18. The systems approach has been used in many other studies undertaken, the subject of which was the city (Parysek, 2006, Mierzejewska, 2009; Parysek & Mierzejewska, 2013, 2014). The systems approach also applied to the approaches to the subject of regional studies and to the definition of the subject of local and spatial management (Parysek, 1997, 2006).
19. For these reasons, getting into the details of this theory, owing to its high degree of cognitive sophistication, is relatively difficult for non-specialists.
20. For these reasons, *Complexity Theories of Cities* apply to both the city and city systems, sometimes to systems in a particular way (Batty, 2009c, 2009d).
21. Urban infrastructure has primarily endogenous functions, i.e. it serves the city's inhabitants. However, some of its components also have exogenous functions, e.g. a production plant that is a workplace for local residents may employ people from outside the city and sell its products not only on the local market.
22. The following cities are proposed: 'ideal', 'sustainable', 'modern', 'better', 'ordinary', 'absent-minded', 'personal', 'intelligent', 'smart', 'leisurely', 'upbeat', 'compact', 'shrinking', 'demolished', 'desolate', 'learning', 'flexible', 'resilient', and more recently: 'for the people', 'kind', 'happy', 'decent', 'of decent inhabitants', 'well-tuned', 'progressive', etc. It may be worth quoting a few, original ones, popular not only in scientific milieus.
23. The search for the cities of the future is not only the goal of city planners, architects, geographers and sociologists, but also of cultural scientists (Rewers, 2005, Nieszczerzewska, 2020).
24. History provides many city conceptions that have turned out to be utopias.
25. This type of competence is available to every local unit regardless of whether it is a city (municipality), an urban-rural commune, or a rural area.
26. The unit which is a leader in the field of theory, methodology and empirical research using quantitative methods.
27. In physical planning units, e.g. in Liege, Leuven and Thessaloniki, there were Mayan inspectors supervising the implementation of investments and their compliance with the approved plans.
28. Techniques, in particular, are what you can get interested in relatively quickly and acquire the right level of knowledge, on the path to more advanced research in the broad field of Complexity Theory, in the cognitive process and practical activities.

29. Often these are publications resulting from international cooperation.

References

Albrechts, L. (2011). Dealing with risk: Achilles'heel of planning? In: Mierzejewska, L., Wdowicka, M. (Eds.). *Contemporary Problems of Urban and Regional Development*, 131-143. Bogucki Wydawnictwo Naukowe, Poznań.

Alfasi, N. & Portugali, J. (2007). Planning rules for a self planning city. *Planning Theory*, 6(2): 164 – 182. DOI: https://doi.org/10.1177/1473095207077587.

Alwang, J., Siegel, P.B. & Jorgensen, S.L. (2001). Vulnerability: A View from Different Disciplines. Social Protection Discussion Paper Series. The World Bank, Washington DC. file:///C:/Users/mierz/Downloads/Vulnerability.pdf

Banaszak, M., Dzięcielski, M., Nikamp, P. & Ratajczak, W. (2015). Self-Organization of spatial systems: From fractal chaos to regular patterns and vice versa. *PLOS ONE*, 10(9). DOI: https://doi.org/10.1371/journal.pone.0136248.

Batty, M. (2005). *Cities and Complexity*. Cambridge, MA, The MIT Press.

Batty, M. (2009a). *Urban Modeling*. Elsevier, London.

Batty, M. (2009b). Cities as a complex systems: Scaling, interaction, newtworks, dynamics and urban morphology. *UCL Working Paper Series*, 131(8): 1-62. Available at: https://discovery.ucl.ac.uk/id/eprint/15183/1/15183.pdf.

Batty, M. (2009c). Generating cities: from the battom up using complexity theory for effective design. In: Alexion, K., Johnson, J., Zamenopoulos, T. (Eds.). *Embracing Complexity Desing London*. 2 -18, Routledge. Available at: http://www.casa.ucl.ac.uk/ASU/LectureB.pdf.

Batty, M. (2009d). Complexity And Emergence In City Systems: Implications For Urban Planning. *Malaysian Journal of Environmental Management*, 10(1): 15-32. Available at: https://journalarticle.ukm.my/2254/1/Artikel_2_MichaelBatty.pdf.

Batty, M. (2010). *Complexity in city systems: Understanding, Evolution and Design*. Routledge, London.

Batty, M. & Marshall, S. (2012). The origins of complexity theory in cities and planning. In: Portugali, J., Meyer, H., Stolk, E. (Eds.). *Complexity Theories of Cities Have Come of Age*, 21-46. Springer, Berlin.

Baynes, T.M. (2009). Complexity in Urban Development and Management Historical Overview and Opportunities. *Journal of Industrial Ecology*, 13(2): 214-227. DOI: https://doi.org/10.1111/j.1530-9290.2009.00123.x.

Berry, B.J.L. (1964). Cities as Systems within Systems of Cities. *Papers and Proceedings of the Regional Science Association*, 13: 147-163.

Bertalanffy von, L. (1950). An Outline of General System Theory. *British Journal of the Philosophy of Science*, 1: 134-165.

Bertalanffy von, L. (1968). *General System Theory: Foundations, Development, Application*. Braziller, New York.

Chisari, O.O., Mastronardi, L.J., Romero, C.A. (2012). Building an Input-Output Model for Buenos Aires City, *MPRA Paper*, 40028. Available at: https://mpra.ub.uni-muenchen.de/40028/1/Building_an_input_output_model_for_Buenos_Aires_City_corrected_.pdf.

Chojnicki, Z. (1961). *Analiza przepływów towarowych w Polsce w układzie międzywojewódzkim* (Analysis of commodity flows in Poland in an inter-regional basis – in Polish). Studia KPZK PAN.

Chojnicki, Z. (1971). Model wzajemnych zależności miedzy systemem społeczno - ekonomicznym a środowiskiem przyrodniczym. *Poznańskie Roczniki Ekonomiczne*, 24: 57-68.

Chojnicki, Z. (1974). Podstawowe założenia modelu systemu przestronnego miast (The basic assumptions of the spacious cities system model – in Polish). *Miasto*, 9: 1-5.

Chojnicki, Z. (1985). Realistyczna koncepcja systemu. Poznań (A realistic conception of the system. Poznan – in Polish). *Sprawozdania Poznańskiego Towarzystwa Przyjaciół Nauk*, 104: 20-24.

Chojnicki, Z. (1988). Terytorialny system społeczny (Territorial social system – in Polish). *Biuletyn KPZK PAN*, 138: 29-49.

Chojnicki, Z. (1989). Koncepcja terytorialnego systemu społecznego (The concept of territorial social system – in Polish). *Przegląd Geograficzny*, 60(3): 491- 510.

Chojnicki, Z. (1996). Region w ujęciu geograficzno-systemowym (The region in geographic and systemic terms – in Polish). In: Czyż, T. (Ed.). *Podstawy regionalizacji geograficznej*, 7-44. Bogucki Wydawnictwo Naukowe, Poznań.

Chojnicki, Z. (1999). Koncepcja terytorialnego systemu społecznego. In T. Czyż (Ed.). Podstawy metodologiczne i teoretyczne geografii. Bogucki Wydawnictwo Naukowe, Poznań.

Chojnicki, Z. (2011). Systemy społeczne jako przedmiot geografii społeczno-ekonomicznej (Social systems as a subject of socio-economic geography – in Polish). In: Mierzejewska, L., Wdowicka, M. (Eds.). *Współczesne problemy rozwoju miast i regionów*, 31– 47. Bogucki Wydawnictwo Naukowe. Poznań.

Christaller, W. (1933). Die Zentralen Orte in Süddeutschland: eine Ökonomisch-Geographische Untersuchung Über die Gesetz Massigkeit der Verbreitung und Entwicklung der Siedlungen mit Städitschen Funktionen (The central places in southern Germany: An economic-geographical study on the law of mass distribution and development of settlements with urban functions – in German). Fischer Verlag.

Cilliers, P. (2000). What can we learn from a Theory of Complexity Emergence. *A Journal of Complexity Issues in Organizations and Managements*, 2: 23 - 33. DOI: 10.1207/S15327000EM0201_03.

Colander, D. & Kupers, R. (2014). *Complexity and the Art of Public Policy: Solving Society's Problems from the Bottom up*. Princeton University Press: Princeton, NJ.

Crawford, F. (2016). What can complexity theory tell us about urban planning. *New Zealand Productivity Commission Research*, 216(2): 1-14. Available at: https://www.treasury.govt.nz/sites/default/files/2024-05/pc-rp-what-can-complexity-theory-tell-us-about-urban-planning.pdf.

Czyż, T. (Ed.) (1966). *Podstawy regionalizacji geograficznej* (Fundamentals of geographical regionalization – in Polish). Bogucki Wydawnictwo Naukowe, Poznań.

Desouza, K.C. & Flanery, T.H. (2013). Designing, planning, and managing resilient cities: A conceptual framework. *Cities*, 35: 89–99. DOI: https://doi.org/10.1016/j.cities.2013.06.003.

Dietzenbacher, E. & Lahr, M.N. (2004). *Wassily Leontieff and Input - Output Economics*. Cambridge University Press, New York.

Dutkowski, M. (2021). Terytorialny zintegrowany system Przyroda–Człowiek–Technika–Kultura (Territorial integrated system of Nature-Man-Technology-Culture – in Polish). In: Mierzejewska, L., Wdowicka, M. (Eds.). *Miasta i regiony w obliczu pandemii COVID-19 i innych wyzwań współczesnego świata*. Bogucki Wydawnictwo Naukowe, Poznań.

Dzięcielski, M. Kourtit, K. Nijkamp, P. Ratajczak, W. (2021). Basius of attraction around large cities. A study of urban interaction space. *Cities*, 119: 103366. DOI: https://doi.org/10.1016/j.cities.2021.103366.

Funck, R.H. & Blum, U.H. (1987). Urban change: a changing process. In: van der Berg, L., Burns, L.S., Klassen, L.H. (Eds.). Spatial cycles. Aldershot, Gower.

Gánti, T. (1986). *Podstawy życia* (*Basics of life* – in Polish). Wiedza Powszechna, Warszawa.

Gehl, J. (2009). *Życie między budynkami. Użytkowanie przestrzeni publicznych* (Life Between Buildings. Use of Public Spaces – in Polish). Wydawnictwo RAM, Kraków.

Gehl, J. (2010). *Cities for people*. Island Press, Washington D.C.

Gzell, S. (2015). Europejskie miasto potrzebuje pomocy (European city needs help – in Polish). *Wiadomości Konserwatorskie*, 43: 33-43. DOI: http://doi:10.17425/WK44EUROCITY.

Haken, H. (1993). Synergetic as a theory of creativity and its planning. In Andersson, A.E., Batten, D.F. Kobayashi, K. Yoshikawa, K. (Eds.). The cosmo-creative society: Logistical networks in dynamic economy. Springer Verlag, Berlin.

Holland, J.H. (2014). *Complexity. A very short introduction*. Oxford University Press.

Horst, A. (1976). *Ekologia człowieka* (Human ecology – in Polish). Wiedza Powszechna, Warszawa.

Ingarden, R. (1987). *Książeczka o człowieku* (A book about man – in Polish). Wydawnictwo Literackie, Kraków.

Jacobs, J. (1961). *The Death and Life of Great American Cities*. Random House and Vintage Books, New York.

Kim, T.J. (1989). *Integrated urban systems modeling: Theory and Applications*. Kluwer Academic Publishers: London.

Kunicki-Goldfinger, W.J.H. (1978). *Podstawy biologii* (Basics of biology – in Polish). PWN, Warszawa.

Lefebvre, H. (2004). *Rhythmanalysis: Space, Time and Everyday Life*. London and New York, Continuum.

Leontief, W. (1966). *Input - Outut Economics*. Oxford University Press, New York.

Lösch, A. (1956). *Location and the space economy*. Yale University Press, New Haven.

Macias, A. (2008). Badanie przepływów materii i energii w praobrazie miejskim. Klasyfikacja krajobrazu. Teoria i praktyka (Study of matter and energy flows in the urban landscape – in Polish). Landscape classification. Theory and practice. *Problemy Ekologii Krajobrazu*, 20: 243-250.

Mierzejewska, L. (2008). Sustainable Development Models. In: Heberle, C., Opp, S.M. (Eds.), *The Planning Of The Spatial Development Of Towns*. Local Sustainable urban development in a globalized world, 77-92. Hampshire, Asgate.

Mierzejewska, L. (2009). *Rozwój zrównoważony miasta: Aspekty poznawcze i praktyczne* (Sustainable development of a city: Cognitive and practical aspects

– in Polish). Wydawnictwo Uniwersytetu im. A. Mickiewicza w Poznaniu, Poznań.

Mierzejewska, L. (2017). Sustainable Development of a City: Systemic Approach. *Problems Of Sustainable Development*, 12(1): 71-78. Available at: https://ph.pollub.pl/index.php/preko/article/view/4999.

Mierzejewska, L. (2020). Urban substructures as a way to build a balanced spatial and functional structure of cities. In: Johnsen, M.S. (Ed.)., *Urban Space: An Overview*, 1-42. Nova Science Publisher.

Mierzejewska, L. (2021). Policentryczność jako model struktury przestrzennej miasta (korzyści, problemy, dylematy)(Polycentricity as a model of the spatial structure of the city (benefits, problems, dilemmas) – in Polish). In: Szafranek, E. (Ed.). *W poszukiwaniu optymalnego modelu miast*a. 243-260. Wydawnictwo Uniwersytetu Opolskiego, Opole.

Mierzejewska, L. (2022). Ujęcia systemowe w dorobku naukowym prof. Jerzego J. Paryska (Systemic approaches in the scientific achievements of prof. Jerzy J. Parysek – in Polish). *Ruch Prawniczy, Ekonomiczny i Socjologiczny*, 84(4): 241–250. DOI: https://doi.org/10.14746/rpeis.2022.84.4.15.

Mierzejewska, L. & Parysek, J. (2014). Integrated planning at the development of city in terms of the diurnal activity of residences. *Bulletin of Geography. Socio–Economic Series*, 25: 143-153. DOI: https://doi.org/10.1515/bog-2014-0035.

Mierzejewska, L., Sikorska-Podyma, K., Wdowicka, M., Lechowska, E. & Modrzewski, B. (2020). City resilience – aspekty planistyczne (City resilience – planning aspects – in Polish). *Rozwój Regionalny i Polityka Regionalna*, 50: 85–101. DOI: https://doi.org/10.14746/rrpr.2020.50.06.

Montgomery, C. (2015). *Miasto szczęśliwe, Jak zmienić nasze życie, zmieniając nasze miasta* (Happy city, how to change our lives by changing our cities – in Polish). Wydawnictwo Wysoki Zamek, Kraków.

Moroni, S. & Chiffi, D. (2021). Complexity and Uncertainty: Implications for Urban Planning. In: Portugali, J. (Ed.)., *Handbook on Cities and Complexity*. Edward Elgar Publishing, Cheltenham.

Moroni, S. & Cozzolino, S. (2019). Action and the city: Emergence, complexity, planning. *Cities*, 90: 42-51. DOI: https://doi.org/10.1016/j.cities.2019.01.039.

Nieszczerzewska, M. (2020). Czy miasto jeszcze może być szczęśliwe? Na marginesie książki Charlesa Montgomery'ego (Can a city still be happy? On the margins of Charles Montgomery's book – in Polish). *Przegląd Kulturoznawczy*, 4(46): 406-423. DOI: 10.4467/20843860PK.20.036.12840.

Nijkamp, P., Banaszak, M., Dzięcielski, M. & Ratajczak, W. (2019). Hexagonal spatial systems in fuzzy gravitation. *Environment and Planning*, 51(2): 393-402. DOI: https://doi.org/10.1177/0308518X18790249.

Odum, E. (1982). *Podstawy ekologii* (Basics of ecology – in Polish). Państwowe Wydawnictwo Rolnicze i Leśne, Warszawa.

Parysek, J. (1985). Planowe kształtowanie środowiska życia człowieka (Planned shaping of the human living environment - in Polish). *Biuletyn Informacyjny IGiPZ PAN*, 52: 33-46

Parysek, J. (1997). *Podstawy gospodarki lokalnej* (Basics of the local economy – in Polish). Wydawnictwo Naukowe Uniwersytetu im. A. Mickiewicza, Poznań.

Parysek, J. (2005). *Miasta polskie na przełomie XX i XXI wieku: rozwój i przekształcenia strukturalne* (Polish cities at the turn of the 20th and 21st centuries: development and structural transformations – in Polish). Bogucki Wydawnictwo Naukowe, Poznań.

Parysek, J. (2006). *Wprowadzenie do gospodarki przestrzennej* (Introduction to spatial management – in Polish). Wydawnictwo Naukowe Uniwersytetu im. A. Mickiewicza w Poznaniu, Poznań.

Parysek, J. (2009). Urban development of Poland after 2003 legal regulation and reality. *Quaestiones Geographicae*, 28(1): 39-47.

Parysek, J. (2010a). Rozwój miast a polityka miejska w Polsce po 1989 roku (Urban development and urban policy in Poland after 1989 – in Polish). In: Ciok, S., Migoń, P. (Eds.), *Przekształcenia struktur regionalnych, Aspekty społeczne, ekonomiczne i przyrodnicze*, 117-132. Uniwersytet Wrocławski, Instytut Geografii i Rozwoju Regionalnego, Wrocław.

Parysek, J. (2010b). Urban policy in the context of contemporary urbanisation processes and development issues of Polish cities. *Journal of Urban and Regional Analysis*, 2(2): 33-44. DOI: https://doi.org/10.37043/JURA.2010.2.2.3.

Parysek, J. (2014). Life of the city. In L. Mierzejewska, J. Parysek (Eds.). Cities in a Complex World: Problems, Challenges and Prospects, 213-224. Bogucki Wydawnictwo Naukowe, Poznań.

Parysek, J. (2015). Miasto w ujęciu systemowym (The city from a systemic perspective – in Polish). *Ruch Prawniczy, Ekonomiczny i Socjologiczny*, 77(1): 27-53. DOI: https://doi.org/10.14746/rpeis.2015.77.1.3.

Parysek, J. (2016a). W poszukiwaniu nowego systemu organizacji, struktury i funkcjonowania gospodarki przestrzennej w Polsce. *Problemy Rozwoju Miast*, 13(1): 39 - 49.

Parysek, J. (2016b). Asking about the future of spatial management in Poland. *Ruch Prawniczy, Ekonomiczny i Socjologiczny*, 78(2): 37 - 58.

Parysek, J. (2019a). Poznań School of Socio - Economic Geography (and Spatial Mangement) of Adam Mickiewicz University (in Poznań). *Quaestiones Geographicae*, 38(2): 7-28. DOI: 10.2478/quageo-2019-0016.

Parysek, J. (2019b). Wkład Profesora Zbyszka Chojnickiego do teorii i metodologii gospodarki przestrzennej. *Rozwój Regionalny i Polityka Regionalna*, 43: 7-24. Available at: https://pressto.amu.edu.pl/index.php/rrpr/article/view/19286.

Parysek, J. (2021). W poszukiwaniu optymalnego modelu miasta (temat z wariacjami) (In search of the optimal city model - theme with variations – in Polish). In: Szafranek, E. (Ed.), *W poszukiwaniu optymalnego modelu miast*, p. 175-200. Uniwersytet Opolski, Opole.

Parysek, J. & Mierzejewska, L. (2013). *Życie miasta: Studium Poznania. Miasto i jego mieszkańcy* (City Life: Poznań Study. The City and Its Inhabitants – in Polish). Bogucki Wydawnictwo Naukowe, Poznań.

Parysek, J. & Mierzejewska, L. (2014). *Życie miasta: studium Poznania. Infrastruktura miejska* (City Life: A Study of Poznań. Urban Infrastructure – in Polish). Bogucki Wydawnictwo Naukowe, Poznań.

Parysek, J. & Mierzejewska, L. (2016). Spatial structure of a city and the mobility of its residents: functional and planning aspects. *Bulletin of Geography. Socio-economic Series*, 34: 91-102. DOI: https://doi.org/10.1515/bog-2016-0037.

Petrisor, A.I. & Petrisor, L.E. (2013). The shifting relationship between urban and spatial planning and the protection of the environment: Romania as a case study. *Present Environment and Sustainable Development*, 7(1): 268- 276. DOI: https://doi.org/10.47743/pesd2023171009.

Portugali, J. (2011). *Complexity, Cognition and the City*. Springer, Berlin.

Portugali, J. (2012a). Complexity theories of cities: Implications to urban planning. In: Portugali, J., Meyer, H., Stolk, E. (Eds.). *Complexity Theories of Cities Have Come of Age*, 221-244. Springer, Berlin.

Portugali, J. (2012b). Complexity theories of cities: First, second or third culture of planning? In: De Roo, G., Hillier, J. Van Wezemael, J. (Eds.). *Complexity and Planning*, 117-140. Farnham, Ashgate.

Portugali, J. (Ed.) (2023). *Handbook on Cities and Complexity*. Cheltenham. UK: Edward Elgar Publishing.

Portugali, J. & Stolk, E. (Eds.) (2016). Complexity, Cognition, Urban Planning and Design. *Post-Proceedings of the 2-nd Delft International Conference*. Springer. DOI: 10.1007/978-3-319-32653-5.

Prigogine, I. (1997). *The End of Certainty. Time, Chaos, and the New Laws of Nature*. The Free Press, New York.

Prigogine, I. & Stengres, I. (1984). *Order out of Chaos. Man's new dialogue with Nature*. Heineman, London.

Rauws, W. (2017). Embracing uncertainty without abandoning planning: Exploring an adaptive planning approach for guiding urban transformations. *The Planning Review*, 53(1): 32-45. DOI: https://doi.org/10.1080/02513625.2017.1316539.

Rewers, E. (2005). *Post-polis: wstęp do filozofii ponowoczesnego miasta* (Post-polis: An Introduction to the Philosophy of the Postmodern City – in Polish). Towarzystwo Autorów i Wydawców Prac Naukowych "Universitas".

Rose, J.F.P. (2019). *Dobrze nastrojone miasto* (A city in a good mood – in Polish). Wydawnictwo Karakter, Kraków.

Sadowski, B. & Chmurzyński, J.A. (1989). Biologiczne mechanizmy zachowania (Biological mechanisms of behavior – in Polish). PWN, Warszawa

Sengupta, U. (2017). Complexity Theory: The urban is a complex adaptive process. In: Iossifova, D., Doll, C., Gasparatos, A. (Eds.), Defining the Urban, Routledge.

Simonienko, K. Murawiec, S. & Tryjanowski P. (Eds.) (2024). *Ekopsychiatria: Jak bliskość natury wspiera nasza psychikę* (Ecopsychiatry: How proximity to nature supports our psyche – in Polish). Sensus, Gliwice.

Timmerman, P. (1981). *Vulnerability, Resilience and the Collapse of Society: A Review of Models and Possible Climatic Applications*. Institute for Environmental Studies. University of Toronto, Toronto, Canada.

Wołoszyn, E. (1997). Koncepcja systemu otwartego Ludwiga von Bertalanffy'ego. *Filozofia Nauki,* V, 1(17): 135-139.

Zimny, H. (1990). *Uwarunkowania ekologiczne i funkcjonowanie przyrody miasta* (Ecological conditions and functioning of the city's nature – in Polish). In: Środowisko przyrodnicze Warszawy. PWN, Warszawa.