Peculiarities of Formation of a Systems Approach in Domestic Urban Planning

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Abstract. The formation of a systems approach to urban planning in Ukraine is considered, starting from the second half of the twentieth century. Territories with a high level of urban planning development were formed at the time as a result of the development of an industrial component of the production industrial complex, which became the basis for perspective formation of urban systems as real entities. The transition to post-industrial relations causes the increase in complexity of urban systems and their study as complex, open, non-linear, socio-territorial entities capable of self-organization as a real process that takes place in their structure.

1. Introduction

Starting from the second half of the nineteenth century, a concentration of production is observed in the largest cities of the most developed countries of Western Europe and the United States as a result of the formation and development of capitalist socio-economic relations. It is accompanied by rapid growth of the urban population and as a consequence by the chaotic growth of cities with an extensive territorial development, formation of urban agglomerations on their basis, that gradually merge among themselves, transforming into «megapolises».

In the context of deepening the process of urbanization in the twentieth century, the necessity of finding new flexible methodological approaches that would provide opportunities for forecasting and managing the development of the largest cities, as well as centers and forms of settlement based on them, becomes paramount. This was facilitated by the emergence and dissemination in the 1960s and 1970s of a general scientific systems approach, an important methodological tool for the study of complex objects and interactions.

2. The urgency

The urgency of applying a systems approach in urban planning is obvious, since the basis of this discipline is the study of urban entities and their evolution as complex systems during the deployment of the process of urbanization in different states and regions.

The study of urban planning objects as a systems has a long tradition. V.I. Vernadsky's doctrine of the biosphere and noosphere; A.O. Grigoriev on the geographical envelope can serve as prominent examples; L.S. Berg on landscapes; M.M. Kolosovsky about territorial production complexes. From the systematic understanding of the evolution of urban networks emerged in 1930 - 1940, the founders of Soviet geography, O.A. Konstantinov (1934) and M.M. Baransky (1946), as well as a well-known specialist in urban planning V.G. Davidovich can be cited. The concept of urban systems of USSR and its regions in the 1960s and 1970s was developed by Yu. G. Saushkin; V.V. Pokshyshevsky; V. Sh. Jaoshvili; N.I. Blazhko; E.I. Pityurenko and other authors.
Novelty of the study in such conditions lies in the further development of the basic principles of the systems approach in their application to urban entities.

3. The main section
In Ukraine, the understanding of the city as a system was formed in the middle of the last century as a result of urbanization of territories. The post-war recovery period is generally coming to an end at that time. Industrialization is picking up the pace as the emphasis in the development of the socio-economic potential of state is placed on the development of the production complex, its industrial component.

The so-called intensively developed areas are manifested as real city-planning entities, which I. O. Fomin considers the starting point in the formation of urban systems in Ukraine settlement systems (SS according to the terminology of the 1980s), which are marked by two main features [1].

Firstly, intensively developed areas are characterized by the presence of negative qualities of the structural organization acquired in the process of formation. The irreversible process of increasing the degree of economic and urban planning usage of the territory led to the deterioration of the natural component state of the environment and impaired ecological balance. It could not determine the necessity of their planning reconstruction. Secondly, in intensively developed areas, systemic features of group forms of settlement appear earlier than in others, among which I. O. Fomin distinguishes the interrelation of parts, hierarchical structure and dynamism.

Urban planning activities, using architectural and planning tools (determined by I. O. Fomin), aimed at improving the quality of various components of the human environment. From these positions the environment is perceived as a series of interrelated objects of architectural and planning design, differing in size of territories, degree of economic development, level of urbanization, functional characteristics, quality of structural planning organization, etc. The most massive and traditional objects of urban planning are the cities and internal structural elements of the city – the main links of the human environment. The intensification of public production, the development and improvement of intercity communication facilities and the growth of diverse needs of the population stimulate the development of connections and interdependence of cities and other settlements. Cities are losing their autonomy and independence, increasingly turning into different by their meaning elements of larger and more complex urban structures. At the same time, the largest cities go beyond their formed administrative boundaries and unfold in space, drawing an increasing number of settlements into their sphere of influence. New large-scale forms of populated areas are emerging [1]. Agglomerations, urban areas, urban zones (in the terminology of the USSR), and megalopolises as urban (above-urban) systems are gradually formed. Back in the 1980s, Ukrainian scientists managed to study and describe the phenomenon of urban systems based on a systems approach, which began to be increasingly used in urban planning and manifested in the systematic interpretation of group forms of urban settlements.

The necessity for perspective improvement of existing forms of settlement seemed obvious due to the manifestation of previously acquired negative properties of their structural organization. It was reflected in long-term targeted programs - General and regional settlement schemes, respectively, on the territory of the Soviet Union and individual republics, that identified the priority of designing urban systems as the most relevant urban planning objects. Thus, at the end of the twentieth century, the concept of planned-regulated formation of settlement systems (SS) emerged.

In determining the ways and means of formation of the SS on the large territory of the Soviet Union, which was characterized by the great diversity of urban planning, economic, historical, national and other features of its individual parts, great attention was paid to local and regional conditions. Therefore, after the collapse of the USSR in the conditions of the formation of market relations in the newly created independent states, including Ukraine, the earlier scientific researches in the field of studying urban systems have become the foundation for the renewal of works on the improvement of settlement systems and the sustainable formation of cities. This was facilitated by the adoption of the Law of Ukraine "On the General Scheme of Planning of the Territory of Ukraine" (Kyiv, February 7, 2002, No. 3059-III), which defined the priorities and conceptual directions of planning and use of the territory of the country for the future. Furthermore, rethinking of understanding of the urbanization process and recognition of its objectivity and historicity by Ukrainian scientists in the end of 1990s assists in this renewal as well.
This approach made it possible to study the patterns and use specific positive experience of world urbanization in solving acute problems on the territory of Ukraine.

Moreover, the methodology of a systems approach that has expanded conceptual apparatus and has been in use for several decades, although it has no universal, generally accepted character and has no standardized interpretation because of the dynamic nature of processes in the field of human activity, basically allows it to be used for solving almost any task, including urban planning.

In 1999 U. L. Pivovarov defined the urban system as a spatial form of settlement of any taxonomic rank that develops around an urbanized nucleus [2]. For example, it is an autonomous city, an urban agglomeration, an urbanized area, an urbanized zone, a megalopolis, for example.

The study of the city as a system includes the use of a number of systems-representations (categories) [3], with the following being the main among them:

1. Structural representation associated with the selection of elements of the urban system and the connections between them. Thus, at a certain level of the city's development as a system, when the agglomeration formed on its basis reaches its "mature" development, a hierarchically organized planning structure of the city center appears from the historical core to the zone of influence, which is superimposed on the planning framework that provides links between individual structural elements.

2. Functional representation of an urban system – an emphasizing of the set of functions (purposeful actions) of the system and its components aimed at achieving a specific goal. The existence of the urban system implies the vital activity of its functional planning organization – the complex formation of separate functional zones, these being production, rural and recreational, and their interaction, interpenetration and relationships.

3. Macroscopic imagery – an understanding of the urban system as an indivisible whole, that interacts with the external environment. That is, the urban system is always considered as a holistic center of a larger hierarchical level in relation to its adjacent territories.

4. A microscopic representation, that is based on the consideration of the urban system as a set of interconnected elements and involves the discovery of the peculiarities of the environment of the structural elements of the city.

5. Hierarchical representation, based on the concept of city subsystems, which is obtained by decomposition of an urban system, that has systemic properties that should be distinguished from its element into smaller parts (in terms of the solving problem). The city system can be represented as sets of subsystems of different levels that make up the system hierarchy, which is closed at the bottom only by elements.

The hierarchical organization of the city as a system in the system of cities was considered in 1964 by the American economist geographer B. Berry.

A city is a complex system, as such it has elements, which in turn are systems acting as subsystems of its larger complex system. When its population exceeds 100 thousand people, the above-urban systems begin to form on its basis – namely, agglomeration, urbanized area, urbanized zone, megalopolis [4].
There are three main subsystems of the city at the most basic level. These are the population, the economic basis, the sphere of life. At the same time, the city is part of a system of higher hierarchical level.

6. A procedural representation that involves understanding of the urban system as a dynamic object, characterized by the sequence of its states over time. Organically applied to the analysis of the city genesis, its further development or degradation, which can be considered as a time-distributed system. In the study and further formation of the urban system, an urban education is considered within the existing administrative boundaries. In the context of agglomeration processes, wherein the industrialization of the city go beyond their traditional boundaries, there is a process of so-called extensive development of the settlement, and settlements of the suburban zone are gradually included in the structural elements of the agglomeration. The city begins to be considered as a singular entity with its suburban zone, and the new boundaries are determined on the basis of the unity of new structural formations, determined by means of connections by the method of taxonomic zoning. Gradually, a hierarchical structure is being formed including not only the urban agglomeration but also the territories external to it. Thus, a model of agglomeration and supra-agglomeration (suburban) systems emerges [5].

Depending on the impact on the environment and the nature of the interaction with other systems, the functions of the urban system may be arranged by their increasing rank:
- passive existence – can be observed in the case of non-prospective settlements, situated far enough from local centers of certain hierarchical levels in the absence of developed transport infrastructure;
- material for other systems – when it comes to the disappearance of non-prospective settlements (completion of “monocities” activity, resettlement after complete destruction in case of natural or man-made disasters, etc.);
- maintenance of higher rank systems – for example, supplying labor and other resources to a city center of the agglomeration from its area of influence;
- opposition to other systems (survival) – observed in the case of the formation of many center agglomerations, when individual centers compete to become the main one;
- absorption of other systems (expansion) – occurs in the process of formation of above-urban systems;
- transformation of other systems and environments (active role) – inherent in the largest cities that can be identified as global (world) cities.

The city is always considered an open system that allows the exchange of energy, matter and information (for example, energy supply, labor, innovation, etc.) with the environment.

In modern conditions of post-industrial society formation, the process of perspective emergence of urban establishment as systems is complicated. There is a stratification of the subject that affects the urban system for the researcher, developer of regulatory documentation, designer, manager, investor, etc. This raises the risk of losing the idea of the integrity of the urban system.

Urban planning development of cities as a system activity cannot be reduced to the development of project documentation only. Moreover, experience in the implementation of district planning projects and master plans for individual settlements shows that even in conditions of a planned economy, it was never possible to fully reach the project indicators, and violations in the master plans of the largest cities were counted in the dozens.

In the context of the global stage of the process of urbanization, the city is considered a complex synthetic object in which the historical, economic, social, political, environmental, biological, natural and scientific laws act coherently and thus determine the existence of common mechanisms of emergence and functioning of the city as a whole.

Attempts to describe the processes of emergence and development of the city, as well as the possibilities of their regulation, are often made with the help of a synergistic approach, which mostly responds to existing challenges. The city itself is considered by this approach as a complex open nonlinear, socio-territorial system capable of self-organization – a synergistic system.

According to V. G. Turkina, synergetics allows to describe many urban processes and phenomena from a single position, allows to study the internal laws of urban systems development, gives basis for certain forecasts related to urban dynamics [6]. The synergetic description, as a rule, shows that the whole arisen as a result of the action of synergetic mechanisms of dynamics, begins to have properties
that were absent in its individual parts and elements. This is fully consistent with the idea of any city. The city is not a simple sum of its separate components, it represents absolutely new object possessing new qualities inherent in it as an integral organism.

Certainly, in the formation of synergistic ideas about the city, the phenomenon of self-organization comes to the fore. Self-organization of the system is the process of evolution of a complex system; the birth of a certain orderly structure with new qualities out of the physical chaos. It includes all processes of self-structuring, self-regulation and self-reproduction.

When it comes to the historical-genetic analysis of the development of society, particularly the formation of the settlement system and its individual elements, the knowledge of laws of self-organization allows us to interpret various social entities as social structures capable of self-organization.

Nonlinear description of the formation of urban systems at certain stages of their historical development involves the formation of different types of such structures, ranging from a single city to a network of cities, agglomerations, megalopolises, that are born, change and interact with each other according to nonlinear laws. Nonlinearity means that many solutions correspond to many ways of evolution of a nonlinear system; it indicates the variety, alternative, and irreversibility of possible ways of system evolution.

The uniqueness of each city is manifested in its genetic code, economic and geographical location, natural conditions, peculiarities of historical, socio-economic, structural and planning, compositional development, silhouette formation, and corresponds to non-linear ideas about cities that can exhibit many possible types of behavior in such conditions. That is, synergetics tries to identify real mechanisms and types of behavior that allow to consider the city as a special dissipative structure capable of self-organization, the emergence of which is associated with certain conditions of the environment that generates it. Dissipativeness (openness) of the city, in other words, means the ability of the system to exchange energy, matter, and (or) information with the outside world.

Cities as real systems that are connected to the environment by many economic, social, political, cultural and other ties, show their dissipation (openness). In the process of formation of above-urban systems, the city draws the suburban space into its limits and at the same time spreads the urban way of life into the adjacent territories.

Under the influence of external factors (political, economic, social, etc.), the city can change its mode of existence from prosperity to decline.

A condition that is steadily maintained by inflows of energy and substance from the outside; the property of an open inhomogeneous urban system, which actively interacts with the environment and is able to acquire dissipativity, is defined as a disequilibrium. However, its individual elements and subsystems may have characteristics that are quite different from the average.

For the urban system, disequilibrium is a rather characteristic condition. For example, the incomes of individual citizens or the housing supply of a single family are quite different from the average. The city is never isolated. The condition of the city, which is perceived as an "equilibrium" at deep examination is not such, but characterizes only a stable period of development of the nonequilibrium structure. According to synergistic consideration, disequilibrium is evaluated as a positive, creative factor of development. Achieving "equilibrium" for each city means the inability to create new socio-economic structures, is perceived as a process that leads to stagnation or even precedes the degeneration and dying [6].

Therefore, the conditions for the emergence and existence of a city system capable of self-organization are the fulfillment of the properties of nonlinearity and dissipation. In this case, self-organization is genetically related to the appearance of small fluctuations in the previous state – a random deviation of the system from equilibrium, when the changes in the external environment are not "noise" but the generator of new structures.

4. Research results
Features of self-organization of the urban system can be considered on the example of an industrial city. Its emergence is primarily based on the development of capitalist socio-economic relations as well as the scientific and technological progress as its consequence. The gradual transition from handicraft to machine production causes the location of industrial enterprises in the structure of cities, the formation
of whole districts and zones on their basis, including storage, municipal and construction territories, as well as the development of transport and engineering infrastructure.

Territorially, the city is growing extensively, going beyond its historical boundaries and absorbing suburban territories and small settlements located therein. Subsequently, its clear structural and planning organization, including the historic core, city center, historical building area, new dispersed planning districts and suburban area, is revealed. All this indicates that the so-called "Big City" is formed with an adjacent area, which, due to the developed intensive connections, can be considered as a single formation. Parts of this formation are "mature" agglomeration, suburban zone, a zone of influence, a zone of joint interests of the center and periphery. The evolutionary stage is unfolding.

At this stage, the city already exhibits systemic qualities that can be described by specific determinations: cause-effect, functional, target, correlative ties and more.

Gradually, the negative effects of industrialization in the industrial city are brought to the fore. There is an uncontrolled development of suburban arrays of various functional purpose and, because of their overlap, the joining of suburban arrays between themselves and the central core of agglomeration, as well as the degradation or even disappearance of open green spaces, expansion of the city center to 100 - 200 square kilometers and more, the emergence of functional-landscape overlap, appearance of large centers of environmental pollution, "recreational urbanization". Fluctuations are increasing.

Even the most stable multifunctional cities show an increase in chaotic processes in their structure during the fall of the main indicators of industrial production in such conditions. This increase is characterized by the appearance of centers of degrading industrial areas.

Settlements formed during the industrial period as the "monocities" with a leading industrial function that provided jobs for up to 90% of the able-bodied population, are facing the problem of the continued existence of the settlement itself. With the increase of entropy (the growth of irreversible processes), losing its stability under the influence of fluctuations, the system enters a nonequilibrium state and approaches the bifurcation phase, which in a physical sense marks the point of branching of the paths of system’s evolution.

1996 can be considered the point of bifurcation for the industrial city that determines its critical condition, when at the Habitat II conference held under the auspices of the UN in Istanbul, the exhaustiveness of the industrial society was declared and the concept of the sustainable development of civilization in the context of the post-industrial era formation was conceived. Of course, this "point" is rather conditional. It was preceded by a transition period for several decades, which saw appearance of socio-economic relations focused on the development of tertiary and quaternary sectors of the economy and the "new industrialization" based on the latest technologies. Some positive experience was gained in restructuring the degraded industrial territories in the structure of cities into the so-called "ecocites", which were recognized as the first sustainable urban settlements.

Therefore, the urban system undergoes two main stages in the process of self-organization - evolitional and bifurcational.

The study of the self-organization of the urban system testifies to its complete compliance with the methodological principles of the full-format synergetic modeling proposed by V. G. Budanov for application in the humanitarian sphere and interdisciplinary design. The theory proposes two structural principles of being - homeostatic and hierarchy – that characterize the phase of "order", the stable functioning of the system. Meanwhile, the principles of formation – nonlinearity, instability, openness, dynamic hierarchy, observability – characterize the phase of transformation, the renewal of the system, ways of destruction of the old order, the chaos of testing alternatives, and the birth of the new order [7].

Passing through the point of bifurcation, the urban system continues its development along one of the possible ways of evolution. Thus, the implementation of the concept of sustainable development in the conditions of the post-industrial technological era formation stimulates the restructuring of cities on the basis of humanization, providing the diverse needs of the population, preserving the natural environment. At the same time, improvements in the economic and political spheres of the country cause new human requirements for housing, social sphere, recreation, which in turn stimulates the development of design, construction, research, etc.
5. Conclusions

1 The systems approach in urban planning in Ukraine begins to be widely used in the second half of the twentieth century, when the emphasis on the development of socio-economic potential of the state were placed on the formation of an industrial component of the production complex, resulting in the formation of territories with high level of urban planning development, which became the basis for perspective formation of urban systems as real entities.

2 In the process of development of agglomeration processes the city begins to be considered as a system in the system of cities. That is, above-urban systems are formed on the basis of cities, and the city acquires a valid hierarchical organization.

3 In the conditions of increasing complexity of urban systems in the process of formation of post-industrial relations, first attempts to describe the processes of their emergence, development and perspective formation are made by means of a synergistic approach.

4 The city is considered a complex open nonlinear, self-organizing socio-territorial system - a synergistic system. The self-organization of the urban system is a real process that takes place in its structure and involves the evolutionary and bifurcational stages of formation.

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