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THEORETICAL AND METHODOLOGICAL FOUNDATIONS OF THE FORMATION OF TERRITORIAL URBAN SYSTEMS

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Abstract. In the article, the formation of the theory of territorial urban systems and urban agglomerations is scientifically and methodologically analyzed. Historical-comparative, structural-structural analysis and content-analysis methods were used. As a result, a three-stage periodization of theory evolution, a comparative classification of four methods of limiting agglomeration and a five-stage algorithm of their complex application are proposed. The initial approval in the case of Andijan agglomeration showed the possibility of practical application of the approach. The conclusions serve as a methodological basis for the quantitative and spatial study of agglomerations of the Fergana Valley.

Keywords: territorial urban system, urban agglomeration, central place theory, urban hierarchy, delimitation of agglomerations, pendular migration.

INTRODUCTION. In the 21st century, urbanization has become one of the main factors of territorial development: according to UN data, in 2018, 55 percent of the world's population lived in cities, and by 2050 this share is expected to reach 68 percent [9]. However, the essence of the process lies not only in the growth of the urban population. At the higher stages of territorial development, it is not individual cities but their functionally connected systems — agglomerations and megalopolises — that come to the forefront. Since no city develops without the surrounding rural areas and without transport and labor links, it is methodologically correct to study a city not as a closed unit but as a node of a system.

In Uzbekistan, and in the Fergana Valley in particular, the population is densely settled, the cities are close to one another, and they are organically connected with irrigated farming areas. For this reason, urbanization here manifests itself less through the growth of individual cities than through their incorporation of the surrounding settlements into their sphere of influence, that is, through agglomeration processes. The increased attention to the development of satellite cities in recent years also makes the scientific substantiation of the patterns of formation of such systems a pressing task.

Nevertheless, three problems persist in the literature. First, the concepts of "agglomeration," "conurbation," and "territorial urban system" are interpreted differently by different authors. Second, there is no single generally recognized method for determining the boundary of an agglomeration; as a result, one and the same territory is shown with different boundaries in different studies. Third, theoretical ideas are scattered across different periods and schools, and their consistency and suitability for local conditions have not been sufficiently systematized.

The aim of the study is to systematize the evolution of the theory of territorial urban systems and urban agglomerations, to comparatively evaluate approaches to the delimitation of agglomerations,

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and to create a methodological basis for studying specific territorial objects, including the Andijan agglomeration.

To this end, the following tasks were set:

- to clarify the basic concepts;
- to periodize the evolution of the theory;
- to classify the tools for assessing the hierarchy of cities and the methods of delimitation;
- to propose an algorithm for their integrated application.

Working hypothesis: relying on a single method in delimiting an agglomeration does not yield a reliable result; a comprehensive approach that combines qualitative and quantitative criteria step by step is more effective.

LITERATURE REVIEW AND METHODS. The study used historical-comparative analysis, a systemic-structural approach, and the substantive analysis of scientific literature (content analysis). The content of the scientific works, monographs, and dissertations on geourbanistics by the following scholars was comparatively analyzed: among foreign scholars, G. Sjoberg, B. Trigger, W. Christaller, A. Oppenheim, A. Weber, A. Lösch, C. Clark, E. Burgess, H. Hoyt, C. Harris, and E. Ullman; among Russian scholars, N. Baransky, V. Masson, B. Litvinsky, M. Dyakonov, E. Rtveladze, A. Sagdullaev, Yu. Saushkin, G. Lappo, E. Persik, V. Listengurt, Kh. Khorev, P. Polyan, and B. Rodoman; and among Uzbek scholars, N. Smirnov, Z. Akramov, T. Raimov, O. Ota-Mirzaev, A. Soliev, E. Akhmedov, A. Kayumov, T. Mallabaev, S. Toshtaeva, D. Begimova, and A. Nizamov. The sources were selected according to three criteria: direct study of a system of cities or of an agglomeration; proposal of a concept, model, or delimitation criterion; and significance for regional geography.

Three indicators were used in the quantitative assessment. According to the Zipf–Stewart rule, the population of the city ranked *r* should be equal to Pr = P1 / r. Jefferson's primacy index is Ip = P1 / P2, where P1 and P2 are the populations of the largest and the second-largest city. P.M. Polyan's maturity coefficient is Kmat = P / (M·m + N·n), where P is the urban population of the agglomeration, M and N are the numbers of cities and small towns, and m and n are their shares in the urban population of the agglomeration; the criterion of formation is K = 1 [4]. Since the study is based on secondary sources, its results are theoretical and methodological in nature; the empirical part (Section 3.7) provides a preliminary description.

RESULTS. A territorial urban system is understood as a set of urban settlements located in a given territory, connected through economic, social, transport, and cultural-everyday links, and forming a single functional whole. According to E.B. Alaev, the integrity of a territorial system is ensured by the links among its components [1]. In an urban system, cities serve as "nodes," while transport and infrastructure communications serve as the "network"; as the number of nodes and the density of links among them increase, the system moves to a new qualitative stage — the agglomeration form. Accordingly, a distinction is made between the "geography of cities" (the network and system of cities of a region or country) and the "geography of the city" (the internal structure of an individual city) [7]; in the study of agglomerations, the first approach takes priority.

The stages of increasing complexity of urban systems can conventionally be represented as follows: an individual city → an urban agglomeration (a core and satellite settlements, with pendular links among them) → a conurbation (a form in which cities directly merge; according to A. Soliev,

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this is not a requirement in an agglomeration) → a megalopolis (a large territorial association of several agglomerations; Gottmann, 1961).

Archaeological studies have noted that in Central Asia, settlements formed on the basis of a hierarchical system according to size: at the top of the system stood a large city (for example, Yerkurgan), surrounded by smaller cities and rural settlements [10]. Thus, the hierarchical dependence between the center and the periphery is not solely a modern phenomenon; it has deep historical roots in the urban-planning tradition of the region. The theory itself developed in three stages (Table 1).

Table 1.

Stages in the evolution of the theory of territorial urban systems

Stage	Period	Leading scholars	Main ideas	Significance for agglomeration theory
I	Mid-19th – early 20th century	J. Kohl, V.P. Semyonov-Tyan-Shansky, A. Weber, P. Geddes	Description of the location of settlements and of distance relations; dependence between the center and the periphery	The concepts of "agglomeration" and "conurbation"; the principle of hierarchical dependence
II	1930s–1970s	W. Christaller, A. Lösch, E. Burgess, H. Hoyt, C. Harris, E. Ullman, C. Clark; N. Baransky, G. Lappo, E. Persik	Models of location and of internal structure; economic-geographical position; Soviet geourbanistics	The ideas of hierarchy and polycentrism; the scientific foundations of the agglomeration
III	Late 20th century – present	N. Smirnov, T. Mallabaev, A. Soliev, S. Toshtaeva, A. Kayumov, A. Nizamov, D. Begimova	National schools; urban potential; quantitative modeling and GIS	Delimitation, typology, and quantitative assessment of agglomerations

Source: compiled by the author on the basis of the analysis of the literature.

At Stage I (mid-19th – early 20th century), the location of cities was described. J. Kohl showed the expediency of locating settlements of the next tier along the main roads radiating from a large city and the secondary networks adjoining them. V.P. Semyonov-Tyan-Shansky (1910) substantiated the location of auxiliary cities along the radii extending from a large city and the economic dependence of the surrounding territories on the center — this became one of the initial foundations of agglomeration theory.

At Stage II, W. Christaller (1933) created central place theory: in a homogeneous territory, cities are arranged along a hexagonal lattice and form a seven-tier hierarchy. The limitation of the theory is that it assumes an "ideal" territory with flat relief and uniform transport opportunities; A. Lösch enriched it with demand density and transport costs and developed a hierarchy of market areas. Models of the internal structure of the city — E. Burgess's concentric model, H. Hoyt's sector model, and the multiple-nuclei model of C. Harris and E. Ullman — complemented C. Clark's regularity that

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"the density of activity declines from the center"; it was the multiple-nuclei model that provided the basis for the idea of the polycentric structure of the agglomeration. In the Soviet school, N. Baransky created the concept of economic-geographical position, while B.B. Rodoman's "polarized landscape" model (1970s) raised the issue of preserving the natural landscape in the course of urban expansion. G.M. Lappo defined the agglomeration as "a new evolutionary stage at which a network of settlements becomes a system" (Lappo, 1997, p. 89) and singled out two features: the close location and dense network of settlements, and the mutual complementarity of the elements. In his view, an agglomeration forms in two ways: "from the city" (satellite settlements appear around a large city) and "from the region" (among several settlements in a resource zone, one becomes dominant and turns into a center) (Lappo, 1997, pp. 90–91).

At Stage III, national schools were formed. In Uzbekistan, the first major work was N. Smirnov's *Cities of the Fergana Valley* (1962); T.N. Mallabaev (1982) divided the historical-geographical development of the valley's large cities into five stages. S.K. Toshtaeva defined the agglomeration as "a complex system of cities and villages located in a small, densely populated territory and connected through various links"; A. Kayumov and A. Nizamov introduced the concept of the "urban potential" of a territory and substantiated that the number of cities and the presence of large cities and agglomerations are indicators of socio-economic potential (Kayumov, Nizamov, 2015). The distinguishing feature of this stage is the enrichment of theoretical ideas with quantitative modeling and GIS technologies.

In the analysis of territorial urban systems, the classification of cities by population size is an important methodological tool. In the specialized scientific literature, cities are divided into the following tiers: up to 10 thousand — very small town; 10–20 thousand — small town; 20–50 thousand — "semi-medium" town; 50–100 thousand — medium-sized city; 100–250 thousand — large city; 250–500 thousand — major city; 500 thousand – 1 million — largest city; 1 million and more — million-plus city [7].

The relationship among cities can be assessed using two indicators. According to the Zipf–Stewart rule, the population of the second city should be equal to 1/2 of that of the first, of the third to 1/3, and of the fourth to 1/4. The rule is rarely fully met in practice, but it serves as a norm for assessing the balance of a system. Under this norm, Ip should be close to 2; a considerably higher value indicates primacy, that is, an excessive concentration of the population in one city ("hypertrophy") and territorial disproportion.

The word "agglomeration" (Lat. *agglomerare* — "to heap up") was first used in industry and geology and then passed into the geography of settlements. The term "urban agglomeration" was introduced into science by A. Weber (1899); P. Geddes developed the concept of "conurbation"; the French geographer M. Rouget called the spread of urban activity beyond the administrative boundary an agglomeration (*Problems of the Study of Urban Agglomerations*, 1988). D.I. Bogorod defined the agglomeration as a group of cities and other settlements compactly located in one territory and connected through economic, labor, and cultural-everyday links [8].

There is no single generally recognized method for identifying an agglomeration. In world practice, the following are mainly applied: a core population of at least 100 thousand people; accessibility of the core within 1.5–2 hours; at least 3 settlements in the zone; a population of satellite cities of at least 50 thousand; and the maturity coefficient [5]. In the USA, a similar concept is the metropolitan statistical area (formerly SMSA, now MSA): it requires an urbanized area with a

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population of at least 50 thousand at the center and at least 25 percent of the employed population of the outlying counties working in the central county (or vice versa) (OMB, 2010). By spatial structure, agglomerations are divided into monocentric and polycentric models; dispersed and linear forms are not independent but are their submodels [3]. In Uzbekistan, the share of single-center agglomerations is high, and in them there are opportunities to strengthen the economies of satellite cities.

The practical application of the theoretical basis comes down to determining the boundary of the agglomeration. In the literature, there are four approaches (Table 2).

Table 2.

Comparative characteristics of the methods of agglomeration delimitation

Method	Essence	Main criterion	Advantages	Limitations
Isochronous	The boundary is drawn at a certain transport-time distance from the core	Transport time of 1.5–2 hours	Reflects the actual mobility of the population; simple to calculate	Time-distance is not uniform across directions; the boundary is not a circle but "star-shaped"
Gravity-based	The "attraction" between two settlements is directly proportional to the product of their populations and inversely proportional to the square of the distance: $F = k \cdot Pi \cdot Pj / d^2$	Threshold value of the attraction index	Compares settlements by a single criterion; convenient for disputed settlements	Sensitive to the choice of parameters; does not directly measure actual flows
Statistical-demographic	Calculated by means of formulas such as the maturity coefficient	Kmat; population and number of settlements	Quantitative and replicable; allows agglomerations to be compared	Dependent on administrative units; static, does not show links
Functional (pendular)	Pendular migration and trade and service flows are studied directly	Share of labor and service flows	Gives the most accurate result	Requires much data and time; systematic data are limited

Source: compiled by the author on the basis of the literature (Payzullayev, 2023; Lappo, 1997, etc.).

Because the strengths and weaknesses of the methods complement one another, a five-stage integrated algorithm is proposed (Figure 1). First, a statistical-demographic screening, which requires the least data, is carried out, and the core and candidate settlements are identified; the isochronous boundary refines the territory according to the transport network; the gravity index resolves the question of disputed boundary settlements; functional analysis serves as the final check; the results are

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mapped as GIS layers and compared, and, if necessary, Stages 1–4 are repeated. The logic of the algorithm is based on the principle of "moving from inexpensive data to expensive data."

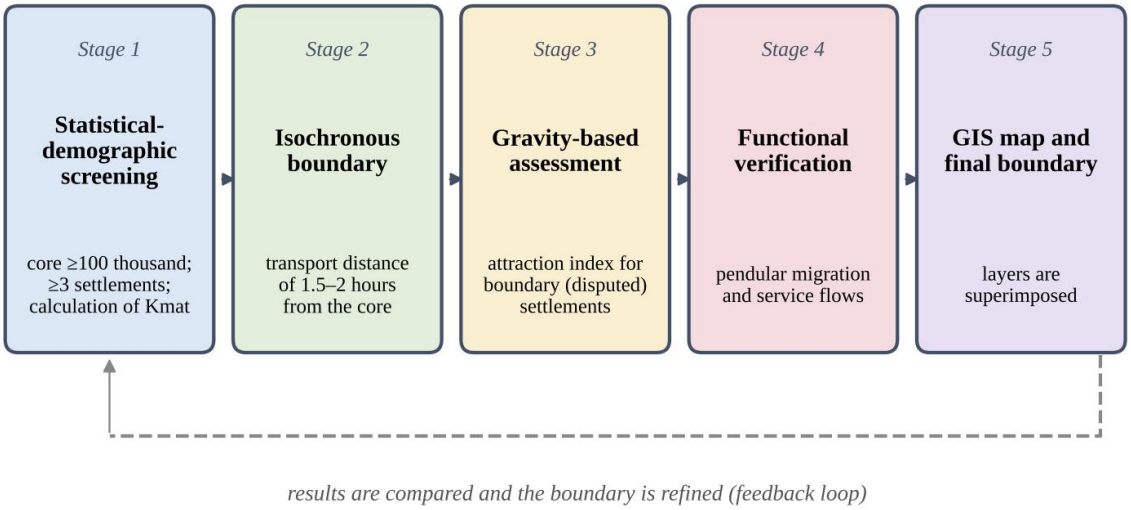


Figure 1. A comprehensive algorithm for determining the boundary of an agglomeration (the author's proposal)

To make a preliminary assessment of the practical application of the approach, the system of cities of Andijan Region was analyzed. The population of the city of Andijan (480.8 thousand people) is 2.37 times larger than the population of the second-largest city (202.6 thousand people), that is, Ip ≈ 2.37, whereas under the Zipf rule a value close to 2 would be expected. Thus, the dominance of the core city in the system — a sign of a monocentric structure — is significant but not yet extremely high. The population of the core is several times higher than the Stage 1 criterion (100 thousand). Functionally, the Andijan–Asaka direction (approximately 11 km) is the densest axis of the agglomeration, and approximately 35–40 thousand people per day are recorded as moving in a pendular manner to the core; two zones are distinguished at radii of approximately 15 and 25 km from the core. These distances fall entirely within the isochronous criterion (1.5–2 hours), that is, Stages 2–4 serve not to narrow but to refine the boundary of the agglomeration (based on the author's calculations and preliminary statistical data).

DISCUSSION. The results confirm that the development of the theory has moved from a descriptive approach to models and quantitative assessment. Importantly, the stages do not negate one another: the ideas of Christaller and Lösch provide the patterns of location, the approaches of Lappo and Begimova provide the internal structure of the agglomeration, and GIS provides their spatial verification. In this sense, the three-stage periodization expresses "layers of approaches" rather than a strict chronology.

The comparison of the delimitation methods supports the hypothesis: each method measures only one aspect of the agglomeration — population size, time-distance, attraction, or actual flows. Statistical methods depend on the administrative boundary, the isochronous method on the transport network, and the gravity method on the choice of parameters; although the functional method is the

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most accurate, it cannot always be applied because systematic data on labor flows are limited. Therefore, in the proposed algorithm, the methods are used as a chain that verifies and complements itself.

The conditions of the Fergana Valley require the local adaptation of classical theories. Christaller's condition of an "ideal plain" is not met here: the location of cities depends on the configuration of foothills, river valleys, irrigated lands, and transport corridors; for this reason, Lösch's model, which takes economic factors into account, is more suitable. Because of the high population density, the boundary between city and village is blurred, which is especially noticeable in agglomerations forming in the "from the city" way. Since expansion may proceed at the expense of irrigated lands, Rodoman's idea of the alternating placement of functional zones becomes relevant: the boundary of an agglomeration must take into account not only the population but also the balance between agriculture and the natural landscape.

CONCLUSION

1. The theory of territorial urban systems has passed through three stages: descriptive (mid-19th – early 20th century), models and hierarchy (1930s–1970s), and national schools and the quantitative-GIS approach (late 20th century – present). The stages express a layered accumulation of approaches.

2. Each of the four methods of agglomeration delimitation (isochronous, gravity-based, statistical-demographic, functional) is limited when taken separately; the five-stage algorithm that combines them step by step increases reliability.

3. The Zipf–Stewart rule and the Jefferson index are tools for the rapid diagnosis of the balance of a system of cities; in the example of Andijan, Ip ≈ 2.37 indicated a monocentric structure.

4. The conditions of the Fergana Valley (complex relief, irrigated agriculture, high density) require the local adaptation of classical theories.

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