

ISSUES OF ENSURING SUSTAINABLE DEVELOPMENT OF URBAN AGGLOMERATIONS: ECONOMIC-ECOLOGICAL AND STRATEGIC APPROACH

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Abstract: This article examines the formation of urban agglomerations, systemic problems in their management, and mechanisms for ensuring sustainable development amidst the acceleration of globalization and urbanization processes. "Centrifugal" problems such as demographic pressure, transport collapse, environmental degradation, and resource scarcity arising in megacities as a result of increasing urbanization levels have been studied from an economic and analytical perspective.

Keywords: urban agglomeration, sustainable development, urbanization, green economy, Smart City, demographic capacity, transport logistics, digital transformation, institutional management.

Introduction. One of the characteristic features of the 21st century economy is the sharp concentration of the world's population and economic resources in major urban centers. According to United Nations (UN) demographic forecasts, by 2050, nearly 68% of the planet's population will live in urban areas [1]. Under these conditions, complex socio-economic systems—urban agglomerations—are emerging that have transcended traditional administrative boundaries and unite the central city and its surrounding satellite territories. From an economic perspective, agglomerations are centers that produce the bulk of the gross domestic product (GDP) due to "economies of scale." [2] Urbanization policy in the Republic of Uzbekistan has also become an important link in the state strategy. The "Digital Uzbekistan - 2030" strategy and new urban planning norms set the task of creating sustainable agglomerations around major cities such as Tashkent, Samarkand, Namangan, and Andijan [4]. Therefore,

researching the scientific and methodological foundations of ensuring the environmental and social sustainability of agglomerations without losing the efficiency of economic growth is one of the most pressing issues today.

Literature review. For many years, the formation of urban agglomerations, their role in the regional economy, and the patterns of sustainable development have been at the center of attention for global and local economists, urbanists, and ecologists. Research in this direction can be conventionally divided into three main groups. The first group includes classical and modern Western economists who researched the fundamental economic foundations of agglomerations and the "territorial scale effect" (agglomeration economies). In particular, A. Marshall proved in his works that the concentration of productive forces in one place yields an external economic effect (external economies), while later P. Krugman and representatives of the new school of economic geography justified the formation of agglomerations through "core-periphery" models [2].

E. Glaeser evaluated modern megacities as humanity's greatest invention, revealing their advantages in ensuring economic growth, innovation, and a "green" lifestyle [3]. However, these studies focus more on economic efficiency and do not provide a deep analysis of the ecological capacity limits of agglomerations. The second group of studies is dedicated to sustainable management of urban systems, reducing environmental impact, and implementing "Smart City" concepts. M. Batty evaluated urban agglomerations as self-organizing complex systems, justifying the need to use mathematical modeling and Big Data analysis in their management [11]. In their work, Z. Allam and Z. Dhunny demonstrated the role of artificial intelligence and digital technologies in optimizing urban infrastructure (transport, energy, waste management) through predictive analysis [12]. Furthermore, international studies emphasize that finding a balance (compromise) between economic interests and environmental safety in the development of agglomerations is the primary criterion for sustainability [13].

CIS economists E. Animov, N. Zubarevich, and L. Limonov investigated the chaotic nature of agglomeration processes in the post-Soviet space, socio-economic

disproportions between the center and satellite cities, and problems of insufficient institutional management [14].

Problems of urban planning, urbanization, and the development of the regional economy in Uzbekistan. Tozhiev A.Kh., Doctor of Economic Sciences. Tojimatov T.T., Doctor of Economic Sciences. This is reflected in the works of local scholars such as Sh.B. Imomov [15]. Issues regarding the integration of "green economy" principles into regional management in the republic have also been systematically analyzed [7]. Local researchers justify the need to abandon traditional urbanization models and transition to intensive and "smart" agglomeration models due to limited land and water resources in the context of demographic growth in Uzbekistan (especially in the Tashkent and Fergana Valley regions) [16].

Methodology. The methodological basis of this study consists of a systems approach, structural-functional analysis, economic-mathematical modeling, and comparative assessment methods. The UN Sustainable Development Goals are widely used in international practice to assess the sustainability of urban agglomerations[5]. Within the framework of the study, two different balance of forces were analyzed to determine the level of agglomeration development: Centripetal forces: Labor concentration, innovation, high level of infrastructure, and market size. Centrifugal forces: High land and housing prices, traffic congestion, increased environmental and tax burden. The indicator of agglomeration stability (I) was expressed using the following conceptual model through the interdependence of economic efficiency (E), social security (S), and environmental safety (En) functions: $I = f(E * S * En)$. In this case, the natural-demographic capacity of the region and the level of resource availability were taken as limiting factors. The analyses are based on empirical data from the World Bank, the Statistics Agency under the President of the Republic of Uzbekistan, and international urban institutions from 2020–2025.

Discussion and results. Analysis shows that the expansion of agglomerations brings economic benefits (multiplicative effect) up to a certain point, and after passing that critical point (optimum boundary), it causes an increase in the scale of

marginalization and losses. When analyzing the volume of daily "magnetic migration" (travel to and from work), it was found that 45-50% of the population of satellite cities works in the center [6]. This increases the load on transport networks exponentially. The transformation of agglomerations into industrial and transport hubs is sharply worsening the air pollution index (API). For example, the Fergana Valley agglomeration (Andijan-Namangan-Fergana conurbation) is one of the most densely populated regions in the world, where urbanization is expanding due to green zones [8]. According to data, the area of green cover in the agglomeration area has decreased by an average of 12% over the last five years [4].

Table 1.

Comparative economic indicators of traditional and sustainable (intelligent) management models for urban agglomerations¹

Metric type	Traditional (chaotic) development model	Sustainable (Green/AI-based) model	Economic/Social Effect
Transport system	Centralized logistics relying on private vehicles	Priority of Public Transport, Intelligent Transport (ITS)	Travel time will be reduced by up to 25%
Power supply	Centralized heat/electrical systems, high losses	Smart Grid system, alternative and renewable energy	Energy losses decrease by 18-20%
Resource usage	Linear economy (production -	Circular economy, 100% recycling of waste	Utility costs will be saved by 15%

¹Author's development

	consumption - waste)		
Territorial planning	Administrative-command, chaotic construction	Digital Twins and ecological zoning	The productivity of urban land use will increase by 30%.

The experience of international agglomerations that have implemented "Smart City" components (Singapore, Seoul, Copenhagen) shows that resource management based on artificial intelligence (AI) significantly reduces urban costs [10]. It has been proven that waste disposal, sensor detection of leaks in water networks, and intelligent lighting systems save the agglomeration budget.

The results obtained show that the spontaneous abandonment of urban agglomerations by administrative command or only by market economy mechanisms leads to catastrophic consequences. As M. Batty emphasized in his urban planning theories, cities are not static architectural objects, but rather complex, continuously changing networked systems [11]. Therefore, to manage the agglomeration, it is necessary to create its "digital twin" (Digital Twin) and simulate all processes. Another important aspect of the problem under discussion is the lack of institutional governance. In the context of Uzbekistan, districts and cities that are part of an agglomeration are considered different administrative-territorial units (for example, the city of Tashkent and the districts of the Tashkent region). Their budgets, land allocation policies, and social plans are not coordinated. This hinders the implementation of a unified transport and utility strategy [7]. As shown in the research of Z. Allam and Z. Dhunny, to achieve sustainability, it is necessary to apply the "15-minute city" concept at the agglomeration level [12]. That is, the population should not have to go to the center for daily needs (work, education, medicine, recreation), all services should be available in the sub-center in its satellite town. This will reduce the transport burden and ensure regional stability.

Conclusions and suggestions. Based on the research results, the following strategic directions and recommendations are put forward to ensure the long-term sustainable development of urban agglomerations:

Administrative and institutional reforms (establishment of agglomeration councils): "Interregional agglomeration management councils" should be established, uniting all administrative units within the agglomeration and having a single budget and strategy. Green infrastructure and environmental planning: Establishing "Green Belts" around cities and along their connecting routes, converting industrial enterprises into ecological clusters, and increasing the share of renewable energy sources to at least 30% [4].

Development of "smart transport" and logistics: Connecting convenient and high-speed public transport networks (metro, high-speed trains, trams) with satellite cities, stimulating the abandonment of private transport. Real-time control of transport systems through artificial intelligence [10]. Transition to a circular economy: Implementation of a 100% disposal and recycling system for waste generated in the agglomeration area using a single cluster method, and transitioning water resources to a circular (recycling) system [2]. The sustainable transformation of agglomerations depends on finding a golden balance between economic profitability, social well-being, and environmental safety.

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