

Urban agglomeration: human-geographical concept in the sustainable development perspective

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ABSTRACT

Urban agglomerations are complex, open, and dynamic territorial systems that play a central role in spatial development, innovation, and societal well-being amid the challenges of globalization, environmental risks, and socio-political instability. In the context of war, forced displacement, and widespread infrastructure damage, urban agglomerations in Ukraine have emerged not only as centers of population concentration but also as crucial hubs for resilience, recovery, and strategic planning.

The purpose of this study is to conceptualize the urban agglomeration as a functional subsystem of the social and geographical system and to develop a structural model that integrates internal subsystems with multilevel external environments. The research aims to identify key elements of internal interaction and external influence, explain the systemic logic of agglomeration dynamics, and determine the role of governance in ensuring sustainability and resilience. The methodological foundation combines a human-geographical approach with systemic, synergistic, and sustainable development paradigms, supported by modeling, typology, content analysis, and analytical synthesis.

Results. The paper presents an original structural model of an urban agglomeration comprising eight interconnected internal subsystems: social, economic, demographic, innovation-technological, architectural-construction, infrastructural-service, transport-logistics, and natural-ecological. These subsystems interact via synergistic mechanisms and form a cohesive internal environment capable of adaptive self-regulation. Particular attention is paid to the governance subsystem, which includes strategic (conceptual planning), executive (implementation of decisions), and monitoring (evaluation and feedback) functions. This subsystem plays a crucial role in managing complexity and ensuring long-term sustainability. The model also systematizes the external environment into three hierarchical levels: regional, national, and global. Each level generates specific political, legal, economic, cultural, and technological impacts that shape agglomeration development. Five types of interaction—internal systemic connections, adaptive feedback loops, energy exchange, resource flows, and information-communication channels—are identified as mechanisms that maintain functional integrity, enable adaptation to external shocks, and support sustainable development trajectories. The proposed model contributes to the theoretical foundation of urban agglomeration studies by bridging disciplinary gaps and integrating spatial, functional, and governance dimensions into a unified systemic framework. It offers practical utility for strategic planning, urban policy design, sustainability assessment, and post-war reconstruction. This framework is especially relevant for countries and regions undergoing crisis or transformation, where resilient urban systems must be built on principles of sustainability, inclusiveness, and interconnectivity.

Keywords: urban agglomeration, social and geographical system, sustainable development, urban management, adaptive system, external environment.

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Introduction. Cities and urban agglomerations play a pivotal role in the contemporary globalized world, concentrating various types of resources (human, financial, innovative, etc.) and functioning as spatial and organizational centers of population settlement that accumulate major flows of energy and information, serving as key elements of the global network [20]. However, the excessive expansion of urbanized areas gives rise to a wide range of challenges, including environmental degradation, social polarization, and unequal access to basic services and resources. In this context, the issue of the formation and development of urban agglomerations in the framework of human geography becomes increasingly relevant – particularly under the imperative to transition toward a sustainable development model that ensures a balance between economic, social, and environmental components.

On the one hand, agglomerations act as powerful

centers of national economic growth and catalysts of modernization and innovation. On the other hand, they represent complex territorial entities that generate significant anthropogenic pressure and elevate the risks of ecosystem depletion and spatial inequality [20]. This binary nature of urban agglomerations—simultaneously productive and vulnerable—necessitates a fundamental rethinking of traditional approaches to their research, planning, and governance. This involves not only formal delineation of agglomeration boundaries and statistical assessment of demographic and economic indicators but also a deeper conceptualization of urban agglomerations as complex, multi-level, and dynamic subsystems within the broader socio-geosystem.

Such a perspective requires an in-depth analysis of their internal structure and governance subsystems, as well as the levels and types of external influences. Given that modern urban agglomerations are

increasingly developing along non-linear trajectories, it is critically important to incorporate the principles of synergetics into their study. Accordingly, contemporary human geography must focus on the development of a new theoretical and methodological framework for the study of urban agglomerations—one that can adequately interpret their nature, dynamics, interactions with the environment, and potential for sustainable development [12, 53]. This includes not only the categorical redefinition of core concepts but also the creation of new methodological tools for spatial analysis, assessment of agglomeration resilience, and the development of integrated planning strategies aligned with the challenges of the twenty-first century.

Particular emphasis in this context is placed on the implementation of Sustainable Development Goal 11: «Make cities and human settlements inclusive, safe, resilient and sustainable». This goal underscores the importance of transforming urbanized spaces in a way that ensures spatial inclusivity, ecological balance, access to housing and transport, among other objectives [23, 53].

While the relevance of this study applies to urban agglomerations in general, it is particularly acute for those in developing countries or regions experiencing turbulence and uncertainty—such as Ukraine. The country not only faces the challenge of rebuilding its war-torn cities but also the necessity of forming a qualitatively new urban space—safe, inclusive, and adaptive [8, 31].

In this regard, the scientific objective of the study is to refine the conceptual and terminological framework of the human-geographical approach to urban agglomerations in the light of sustainable development principles. At the same time, a key practical task lies in the development of strategic models for the spatial planning of agglomerations that incorporate social equity, ecological balance, and economic viability [23, 27]. Of particular importance is the search for mechanisms to integrate agglomeration structures into national and regional spatial development policies, taking into account population needs, environmental challenges, and the potential of digitalization in governance processes [21, 30].

Thus, there is a growing need for a comprehensive scientific understanding of urban agglomerations as key objects of the spatial organization of society – one that is grounded in the principle of balance between development and preservation, between economic efficiency and environmental safety, and between local interests and global commitments. Such an approach is not only theoretically justified but also practically essential for achieving Sustainable Development Goal 11 and ensuring a viable urban future.

Analysis of Recent Research and Publications. With the emergence of megacities and global-

level urban agglomerations, these forms of urbanized territories have become powerful centers not only for the concentration of various types of resources but also for the accumulation of pressing global challenges [9, 19]. In many countries, the process of urbanization has assumed an uncontrolled character, necessitating deep reflection by the academic community and the active involvement of a broad range of stakeholders—including government, civil society, and business [38].

A significant milestone in shaping the modern European urban development model was the Charter of European Cities Towards Sustainability (Denmark, 1994), which laid the foundations for long-term urban development strategies with an emphasis on quality of life, environmental protection, and balanced spatial planning. In 2007, the Leipzig Charter was adopted, recognizing urban agglomerations as anchor points of Europe's polycentric territorial system, capable of fostering balanced regional development and modernization of institutional governance frameworks [33].

In response to growing global challenges—including climate threats, demographic shifts, urban fragmentation, and social inequality—the New Leipzig Charter was endorsed in 2020. It proposed an innovative vision of the city as a “laboratory for solving global problems,” with a particular emphasis on large cities and agglomerations as spatial entities capable of ensuring inclusivity, compactness, functional diversity, and resilience, based on cultural, social, ecological, and economic interactions.

Urban agglomeration is thus a multidimensional and interdisciplinary research object that encompasses social, economic, demographic, cultural, ecological, and infrastructural elements. Within the structure of the socio-geosystem, it functions as a meso-level unit of society's spatial organization [21, 32]. Urban agglomerations are therefore defined as key functional nodes within the global urban system, whose efficiency significantly influences the realization of sustainable development goals [53].

The theoretical and methodological basis for the study of cities and urban agglomerations in human-geographical research was laid by Walter Christaller's central place theory. It justified the hierarchical organization of settlements and their spatial distribution as a result of market forces, accessibility, and functional division of labor. This theory introduced the concept of a dominant city—essentially an urban agglomeration—as a spatial form for organizing urban functions [6].

Subsequent conceptual development was influenced by John Friedmann's theory of world cities, which viewed megacities as the primary nodes of global control and economic coordination [11]. Saskia Sassen elaborated this concept further by

introducing the idea of the global city as a space with high concentrations of financial institutions, advanced services, and transnational functions. Together, these concepts established a foundation for understanding cities and urban agglomerations as central elements of the global urban system [51].

Peter Hall's work expanded the notion of polycentric urban structures, presenting cities not as monolithic cores but as composed of multiple interconnected centers. This model is especially relevant to contemporary urban agglomerations, which increasingly take on multi-nodal configurations [15]. In a similar vein, Manuel Castells proposed the concept of networked urbanism, where the city functions as a communicative network linking sites of intense information exchange and knowledge production within the global economy.

In the context of the non-linear dynamics of urban systems, the principles of synergetics have become particularly significant [5]. The ideas of Hermann Haken and Ilya Prigogine enable us to consider urban agglomerations as open, non-linear systems capable of self-organization, adaptation, and resilience in response to both internal and external disturbances. This becomes especially relevant in analyzing the adaptive behavior of urban agglomerations under crisis conditions—whether of natural or anthropogenic origin [14, 49].

Edward Soja's perspective on the post-industrial city as a fragmented, hybrid space characterized by multi-vector spatial identity also contributes to this discourse. In this view, cities and urban agglomerations represent intersections of real and virtual spaces, where traditional boundaries dissolve, and discreteness gives way to continuity [52].

Contemporary studies increasingly extend the typology of agglomeration forms to include megalopolises, mega-regions, and technopolises as examples of innovation-oriented urban clusters. Research on current urbanization processes and the formation of urban agglomerations is attracting growing attention from scholars in various disciplines.

An analysis of Ukrainian academic literature on urbanization and agglomeration development reveals the object's pronounced interdisciplinary nature. Human geographers – such as Yu. Pityurenko [47], H. Topchiiev [54], O. Shablii [55], Ye. Marunyak [35], S. Kostrikov [18], Yu. Palekha [44], V. Poruchynskyi [48], R. Lozynskyi [34], K. Mezentshev [36, 37], H. Pidhrushnyi [45, 46], I. Pylypenko [50] – alongside experts in related fields such as M. Babaiev [1], L. Bychenko [4], M. Diomin [7], and S. Bohachov [3], have addressed various dimensions of urban agglomeration development, including geo-urbanistic, economic, administrative, social, ecological, urban planning, legal, and other aspects.

Given the new challenges of decentralization,

post-war transformation, climate change, and population mobility, there is a pressing need to develop a comprehensive, interdisciplinary methodology for studying urban agglomerations in both Ukraine and the global context.

In our previous studies, we have explored the features of urban agglomeration formation and development from the perspective of human geography—particularly in the case of Kharkiv Oblast. We have analyzed global agglomerations through the lens of synergetic theory, investigated global cities and urban agglomerations, and examined the prospects for human-geographical research on agglomerations [19–31, 39]. We have also considered methods and approaches for delineating urban agglomeration boundaries in the spatial dimension.

However, in our view, one of the most pressing theoretical and methodological tasks is the development of a structural model that would clarify the internal environment of an urban agglomeration, the influences of the external environment, and their constituent elements.

Urban agglomerations are urbanized areas functioning as complex spatial entities characterized by a high degree of socio-economic, infrastructural, and informational interaction. While recent academic discourse has paid considerable attention to the spatial organization of agglomerations—their morphological types, hierarchies, and boundary delimitation—less attention has been given to their functional structure as subsystems of the socio-geosystem. Specifically under-researched are the internal interactions between subsystems, the mechanisms of system support and adaptability, and the degree of openness and resilience to external influences.

Equally underexplored are the processes of interaction between urban agglomerations and the external environment. Most existing studies treat the external environment in a fragmented way, lacking adequate systematization of its structural levels, directions of influence, and types of linkages.

Moreover, the issue of agglomeration governance remains highly relevant. Urban agglomerations function as complex, open systems that require effective coordination among subsystems, real-time monitoring of system status, and the capacity to respond to challenges such as socio-economic polarization, environmental threats, and transport congestion. As of now, there is no unified model of governance interventions that allows for strategic planning, regulation, and control of agglomeration development in dynamic environments.

In the context of transitioning to a sustainable development paradigm, particular attention must be paid to the interrelations between the internal elements of agglomerations and external factors influencing the achievement of balance across the social,

economic, and environmental dimensions of sustainability. The key problem lies in the absence of a comprehensive, scientifically grounded model that would systematize all agglomeration subsystems, define types of interactions among them, and determine the role of the governance subsystem in implementing sustainable development strategies

Methods. *The aim of the study* is to develop a conceptual understanding of the urban agglomeration as a complex subsystem of the socio-geosystem in the context of implementing the principles of sustainable development, to construct a structural model of its organization, and to substantiate the functional interaction between its internal subsystems and external influences. The research employs a human-geographical approach, which allows urban agglomerations to be considered as complex elements within the «society–nature–economy» system; a systems approach, which provides a holistic view of the agglomeration's internal structure as an interconnected set of functional subsystems and their linkages with the external environment; a synergetic approach, which enables the analysis of the agglomeration's capacity for self-regulation, resilience, equilibrium, and adaptation under external disturbances; and the concept of sustainable development as a methodological foundation for analyzing the transformation of urban agglomerations in accordance with its goals and objectives. Throughout the study, several methods were applied: the modeling method was used to construct the structural model of the urban agglomeration; content analysis served to explore relevant scientific sources, theoretical concepts, and development programs; analytical synthesis was employed to summarize interdisciplinary approaches; the typological method was used for the classification of internal subsystems; the graphical-analytical method supported the visualization of the structural model and its components; and the method of analogy was applied to adapt effective global practices for the governance of urban agglomerations.

Results. Given the complexity of urban agglomeration structures and their inherent functions, a pressing scientific task is to develop models that consider not only their internal configuration but also their adaptive interactions with regional, national, and global environments. This approach allows not only for a description of the spatial-functional organization of the urban agglomeration but also for an analysis of its potential for sustainable development under conditions of uncertainty. The term *urban agglomeration* is herein proposed to be understood as «a complex, open, and dynamic spatial-functional subsystem of the socio-geosystem, formed through the integration of a central settlement core with surrounding urbanized territories, characterized by intensive internal linkages, a hierarchical structure, the

capacity for self-organization and adaptation, as well as the ability for self-development under the influence of external and internal factors through fluctuations, bifurcation points, and phase transitions that determine its further development trajectory». The urban agglomeration functions as a component of the socio-geosystem, which is marked by the interconnection of its subsystems, the presence of multilevel linkages, synergetic properties, and adaptive capacity. It possesses an integrated structure comprising an internal environment, a governance subsystem, and an external environment composed of various hierarchical levels [30]. Within the framework of the urban agglomeration model, the internal environment is conceptualized as a complex, interconnected system consisting of eight key subsystems that ensure its viability, integrity, and operational resilience: social, economic, demographic, innovation-technological, architectural-construction, infrastructure-service, transport-logistics, and natural-ecological (Fig. 1) [12, 14].

The *social subsystem* of an urban agglomeration represents a key element of its internal environment, reflecting the qualitative characteristics of the population's living conditions, the level of social integration, accessibility to basic services, and the degree of development of social capital. It plays a critical role in shaping an inclusive, cohesive, and adaptive social space that ensures the stability, resilience, and viability of the urban agglomeration [35, 27]. The social subsystem is closely integrated with the demographic subsystem, which includes population characteristics (such as total population, age and gender structure, ethnic composition, migration, and mobility); with the infrastructure subsystem (covering health care, education, social protection institutions, and cultural and recreational facilities), ensuring a decent standard and quality of life (housing conditions, income levels, access to services); and with indicators of social mobility and cohesion (integration of vulnerable groups, public participation in decision-making, local identities), as well as security parameters (law and order, population's sense of safety) [54].

Functionally, the social subsystem supports social equity, fosters mechanisms of social integration, and responds to external threats—including natural, anthropogenic, epidemiological, and military shocks. A specific feature of this subsystem is its spatial heterogeneity, manifesting in the uneven distribution of social benefits between the core and the periphery of the urban agglomeration [2]. In Ukraine, these phenomena have been exacerbated by internal migration and forced population displacement due to military conflict. Within the framework of the UN Sustainable Development Goal 11 ("make cities and human settlements inclusive, safe, resilient, and sustainable"), the social subsystem is not only an object affected by



Fig. 1. Internal Environment of an Urban Agglomeration (compiled by the author)

urban transformation but also an active agent in shaping a qualitatively new urban space [53]. It serves as an indicator of progress toward social justice, inclusiveness, and equal access to resources and services – all of which directly influence the resilience of the urban agglomeration.

The *natural-ecological subsystem* of the urban agglomeration is another core component of its internal environment, ensuring ecological balance and the capacity of the urban space to adapt to climate and technogenic challenges. It includes both natural components of the agglomeration environment (green zones, water bodies, soils) and anthropogenically transformed elements of ecological significance—such as industrial areas, transport infrastructure, solid waste disposal sites, wastewater treatment facilities, and water supply and drainage systems [8, 23]. Within urban agglomerations, the natural-ecological subsystem operates under constant intensive pressure due to high population density and the presence of industrial facilities [1].

Its key functions include maintaining environmental balance, environmental protection, creating a comfortable living environment, securing natural resources for human activity, and implementing spatial zoning that accounts for environmental constraints and risks. It plays a buffer role between the urban core and the external environment, absorbing part of the environmental burden, regulating microclimates, purifying air, and more. Structurally, the natural-ecological subsystem consists of green infrastructure (parks, squares, forest parks, gardens, and recreational areas); water systems (rivers, lakes, reservoirs, stormwater infrastructure); land resources (urban soils, regeneration zones); environmental quality support services (air purification, temperature regula-

tion, hydrological balance maintenance); and a system for environmental monitoring and risk management [9]. It is closely linked to other subsystems—particularly infrastructure, transport, architectural-construction, and social—since environmental conditions directly affect human health, living standards, safety, and overall quality of life. This subsystem acquires special significance in the context of global ecological change and climate policy implementation [16]. Critical tasks include climate change adaptation, reduction of greenhouse gas emissions, waste management, remediation of contaminated sites, expansion and quality improvement of green areas, and conservation of natural reserves. These efforts are central to ensuring the sustainable development of urban agglomerations. Moreover, the integration of “green” and “blue” infrastructure principles into urban planning systems remains equally vital [38]. In the context of the UN Sustainable Development Goals, the natural-ecological subsystem is directly related to Goals 6 (clean water and sanitation), 11 (sustainable cities and communities), 13 (climate action), 14 (life below water), and 15 (life on land). Its effective functioning is a prerequisite not only for environmental but also for social and economic resilience of the urban agglomeration [53].

The *economic subsystem* is one of the core elements of an urban agglomeration’s internal environment, as it determines the level of resource provision, competitiveness, investment attractiveness, and the overall development of the entire system. Its functioning is based on the interaction among entrepreneurial, industrial, service, financial, and innovation sectors, which ensure the circulation of material and financial flows, job creation, generation of gross regional product, and the filling of local budgets [3].

The economic subsystem serves as a foundation for social stability, structural transformation, and the spatial growth of the agglomeration [4].

Its structural components include industrial clusters, business centers, labor markets, development institutions (such as technoparks and business incubators), agro-industrial zones, trade and logistics complexes, as well as small and medium-sized enterprises. The subsystem exhibits spatial heterogeneity and displays uneven patterns of economic activity within the agglomeration. The central core is typically characterized by higher economic activity, while in a post-industrial society it tends to concentrate information flows and innovation. The periphery, in contrast, demonstrates lower levels of economic activity and often hosts industrial and agro-industrial functions [2, 35].

The *primary functions* of the economic subsystem include ensuring population employment, creating conditions for investment and entrepreneurship, supporting regional specialization, and integrating into global economic networks. It also facilitates the development of business support infrastructure and maintains the financial self-sufficiency of territories [43]. In addition, it provides social transfers through taxation systems, supports the development of transport and social infrastructure, and contributes to the modernization of other subsystems through innovative products and services.

In the context of sustainable urban development, the economic subsystem must ensure not only growth but also balance. This implies a transition to a “green economy” model, the development of circular production, the promotion of innovation, and investment in socially and environmentally significant sectors. Particularly important is the transformation of industrial potential in agglomeration centers toward high-tech, energy-efficient, and environmentally neutral production.

In the current context of global instability, warfare, infrastructure destruction, and disrupted logistics in Ukraine, the adaptability of the economic subsystem becomes critical for territorial recovery and subsequent growth. Urban agglomerations have the potential to serve as engines of recovery, as they concentrate the country's key financial-industrial, educational-scientific, and labor resources. The restoration of production chains, attraction of foreign investment, and development of innovation-oriented environments are essential elements of strategic economic governance [4].

The economic subsystem is closely interconnected with other internal components of the urban agglomeration. It requires high-quality infrastructure (transport and utilities), an educated and healthy population (social subsystem), a favorable ecological environment, effective spatial planning, and efficient

governance. Its performance directly determines the agglomeration's resilience to external shocks and crises, as well as its capacity for self-development [31, 38].

Within the framework of the UN Sustainable Development Goals, the economic subsystem is primarily linked to Goals 8 (Decent Work and Economic Growth), 9 (Industry, Innovation, and Infrastructure), 11 (Sustainable Cities and Communities), and 12 (Responsible Consumption and Production). Its functional integration into the urban agglomeration model ensures the coherence of the socio-geosystem, development dynamism, and achievement of economic resilience [53].

The *demographic subsystem* ensures the reproduction of human capital and is a critical element of the urban agglomeration's internal environment, as human capital determines not only the quantitative but also the qualitative parameters of its socio-economic and spatial development. This subsystem forms the foundation for the functioning of other urban components—from labor resources to consumers of goods and services [48].

Key characteristics of the demographic subsystem include total and population density, age, gender, and ethnic composition, migration flows, and other components of demographic dynamics. Also important are the population distribution between the core, satellite cities, and peripheral areas; urbanization indicators (urbanization level, share of urban and suburban population); and settlement patterns (polycentric or monocentric). The subsystem is dynamic and sensitive to internal and external challenges—economic, political, environmental, and security-related. This sensitivity is especially evident during times of crisis: war, economic recessions, or pandemics. Demographic shifts such as depopulation, aging, deurbanization, and internal displacement significantly impact urban planning, demand for housing, education and healthcare services, transportation load, and the capacity of social infrastructure [54, 55]. *Functionally*, the demographic subsystem provides labor resources for the economic subsystem, serves as a basis for spatial planning (based on population density and settlement structure), and generates social demand for infrastructure (schools, hospitals, transport). It supports the cultural and linguistic environment as part of social integration and stimulates innovation through youth clusters and mobile population groups. Currently, the demographic subsystem of Ukrainian urban agglomerations is undergoing significant transformation. Mass internal displacement, war-related population losses, complex security conditions in the East, North, and South of Ukraine, and the temporary occupation of territories pose substantial challenges to the recovery of affected agglomerations. At the same time, the demographic potential

of Ukrainian urban agglomerations that have received large numbers of displaced persons may either strengthen or overburden local life-support systems [26, 31].

From the standpoint of sustainable development, demographic resilience becomes particularly important—i.e., the ability of urban agglomerations to maintain adequate population levels, ensure population renewal, and reduce depopulation. This requires the development of programs to support young families, ensure access to affordable housing, create safe environments, and provide services for all age groups [25]. Within the framework of the UN Sustainable Development Goals, the demographic subsystem is closely related to Goals 3 (Good Health and Well-Being), 4 (Quality Education), 5 (Gender Equality), 10 (Reduced Inequality), and 11 (Sustainable Cities and Communities). Its effective functioning is a key prerequisite for long-term agglomeration resilience and for the realization of the “city for people” concept [53].

The *innovation and technological subsystem* of an urban agglomeration serves as a catalyst for development and modernization, ensuring competitiveness and sustainable growth. It encompasses a wide range of institutions, including research organizations, higher education institutions, technology parks, business incubators, innovation clusters, as well as IT infrastructure, smart city management systems, and digital services that facilitate the generation, transfer, and implementation of cutting-edge knowledge, technologies, and solutions across all domains of urban life and beyond [5, 16].

The innovation-technological subsystem ensures the agglomeration’s competitiveness, modernization, and implementation of innovative solutions toward sustainable development. It is oriented toward the generation, dissemination, and application of innovation across all other urban subsystems. Its structural components include academic and research institutions, business incubators, technology parks, innovation clusters, IT companies and digital platforms, smart city infrastructure, and urban digital services [10].

Key functional roles of the innovation-technological subsystem include the generation of innovations (through R&D at universities and research centers), dissemination of technologies (adapting new solutions for housing and utilities, transport, architecture, medicine, education), digitization of governance (e-governance systems, open data platforms, intelligent decision-support tools), and fostering a creative environment (supporting start-up culture, tech festivals, educational hubs, and platforms for “government-community-business” interaction) [10, 21].

The innovation-technological subsystem is directly linked to the United Nations Sustainable Development Goals (SDGs). In particular, it contributes

to the achievement of SDG 4 (ensuring quality education and fostering scientific potential), SDG 9 (promoting industry, innovation, and infrastructure), SDG 11 (building sustainable and technologically advanced cities), and SDG 17 (developing partnerships for the implementation of innovations) [53]. Its ability to respond adaptively to external challenges—such as war, energy crises, economic recessions, or global technological shifts (e.g., artificial intelligence, renewable energy, 5G, autonomous transport)—is of particular importance. In the post-war recovery of Ukrainian urban agglomerations, this subsystem will act as a “locomotive” of reconstruction through the development of new construction materials, green technologies, digital infrastructure management platforms, and innovations in security, logistics, and energy systems [21].

The effectiveness of this subsystem depends largely on the availability of human capital, investment attractiveness, intersectoral cooperation, and the presence of a strong research and educational environment capable of generating knowledge and preparing specialists. Its integration into the economic, social, and governance structures of the agglomeration enables job creation, enhances service quality, promotes inclusive territorial development, and reduces the digital divide. This subsystem plays a vital role in achieving SDGs 9 (Industry, Innovation and Infrastructure), 11 (Sustainable Cities and Communities), 4 (Quality Education), and 17 (Partnerships for the Goals). The application of innovation and technology within urban agglomerations is a critical condition for their resilience, mobility, ecological responsibility, and self-renewal capacity in a rapidly changing global environment. Thus, the innovation-technological subsystem not only transforms urban agglomerations but also defines their future development trajectory—from consumers to generators of innovative solutions, knowledge, and technologies [53].

The *architectural and construction subsystem* of an urban agglomeration fulfills the fundamental function of shaping the anthropogenically transformed physical environment in which population life processes unfold. It encompasses urban development, functional zoning, urban landscape morphology, street and road network structure, types of residential and public buildings, architectural design of urban infrastructure facilities, and the spatial logic of the location of key functional centers and subcenters within the urban agglomeration [1, 3]. This subsystem embodies urban concepts and strategies through construction, design, renovation, and technical modernization of infrastructure. It plays a crucial role in determining the comfort, safety, attractiveness, and functionality of the urban environment and in shaping the visual identity and emotional perception of the urban agglomeration for residents and visitors

alike [7].

Its *functional efficiency* depends on its capacity to adapt to contemporary urban challenges such as increasing urban density, gentrification, and other transformation processes. It must also address the need for architectural principles that prioritize safety. In the context of rebuilding Ukrainian cities after large-scale destruction, this subsystem is tasked with creating a new urban morphology grounded in principles of sustainability, energy efficiency, barrier-free access, digitalization, and spatial justice [17].

The *architectural and construction subsystem* creates urban space not only for living but also for working, recreation, communication, and socialization. Its effective functioning fosters polycentric spatial models, reduces commuter migration, enhances the attractiveness of peripheral zones, and optimizes resource use within the agglomeration [2, 30]. New architectural approaches emphasize inclusive design, industrial zone revitalization, and preservation of cultural heritage. Key areas for development include implementing sustainable building standards, constructing energy-efficient housing, harmonizing building height with the natural environment, designing adaptive and inclusive public spaces, and integrating architectural planning with natural and landscape features. The alignment of the architectural-construction subsystem with other agglomeration subsystems ensures systemic integrity and high-quality urban environments. It is not only the technical foundation of urban space but also an indicator of economic development [1, 4].

This subsystem directly supports the achievement of multiple SDGs, particularly SDG 11 (Sustainable Cities and Communities), by shaping safe, inclusive, accessible, and ecologically balanced urban spaces with quality housing and effective zoning. Under SDG 9 (Industry, Innovation and Infrastructure), it incorporates advanced construction technologies, energy-efficient materials, and intelligent design solutions.

The infrastructure and service subsystem of the urban agglomeration plays a crucial role in ensuring basic living conditions and in shaping a high-quality urban environment. It encompasses a wide range of service functions, including water and electricity supply, gas and heat provision, sanitation systems, household services, and social, cultural, medical, educational, administrative, and utility infrastructure. Its performance directly influences urban comfort, safety, social inclusion, and resident well-being, while also acting as a determinant of urban resilience [27, 54].

This subsystem interacts closely with other components of the internal environment. It supports the social subsystem through access to health care, education, and social services; the economic subsystem

through logistics and business services; and the ecological subsystem via waste management, recycling, and resource control. The balanced operation of this subsystem is a prerequisite for creating competitive, inclusive, and environmentally responsible urban spaces [36]. Within the context of sustainable development, the infrastructure and service subsystem corresponds to SDG 3 (Good Health and Well-Being) through quality healthcare access, SDG 4 (Quality Education) through educational infrastructure, SDG 6 (Clean Water and Sanitation), and SDG 11 as a basic mechanism for enabling safe, inclusive, and resilient cities [53].

The *transport and logistics subsystem* is a critically important component of the internal environment of an urban agglomeration. It ensures spatial connectivity within the agglomeration, links to external environments, population mobility, economic functioning, and integration of the agglomeration space. It includes systems of passenger and freight transport, urban and suburban transport infrastructure, intercity and international transport corridors, stations and airports, logistics hubs, sorting facilities, and transport communication nodes. The effectiveness of this subsystem significantly influences the dynamics of socio-economic development, territorial investment attractiveness, quality of daily life, and environmental conditions [28, 55].

It serves as the connective framework that links the urban agglomeration core with peripheral areas, ensuring the circulation of people, goods, services, resources, and information. It contributes to the expansion of the agglomeration's spatial field, improves transport accessibility, reduces time costs, and increases productivity. Closely interacting with other subsystems, it supports economic activity (by enabling logistics and business functions), social processes (by ensuring service access), ecological sustainability (by influencing emissions and noise levels), and architectural planning (by shaping the basis for spatial planning and zoning) [29].

Within the framework of sustainable development, this subsystem corresponds to SDGs such as SDG 7 (Affordable and Clean Energy) through energy-efficient transport systems, SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action). The transport and logistics subsystem thus functions not only as the infrastructural backbone of the agglomeration but also as a powerful regulator of its spatial organization, socio-economic dynamics, and environmental resilience. Its modernization is a vital precondition for ensuring the sustainable, integrated, and balanced development of urban agglomerations [53].

In conclusion, each subsystem fulfills specific functions while forming part of a unified systemic

entity that ensures adaptability and functional integrity of the agglomeration. The interconnections among these subsystems are systemic in nature, facilitating the exchange of resources, information, and energy, as well as the implementation of governance measures.

The next structural level of the model is represented by the agglomeration *administrative system*,

which includes *management, executive, and monitoring* subsystems. These components are essential for adapting internal processes to changes in the external environment and for ensuring comprehensive urban agglomeration governance (Figure 2) [41, 42].

The *management subsystem* is a key component of the governance system of an urban agglomeration. It defines the long-term development trajectory, est-

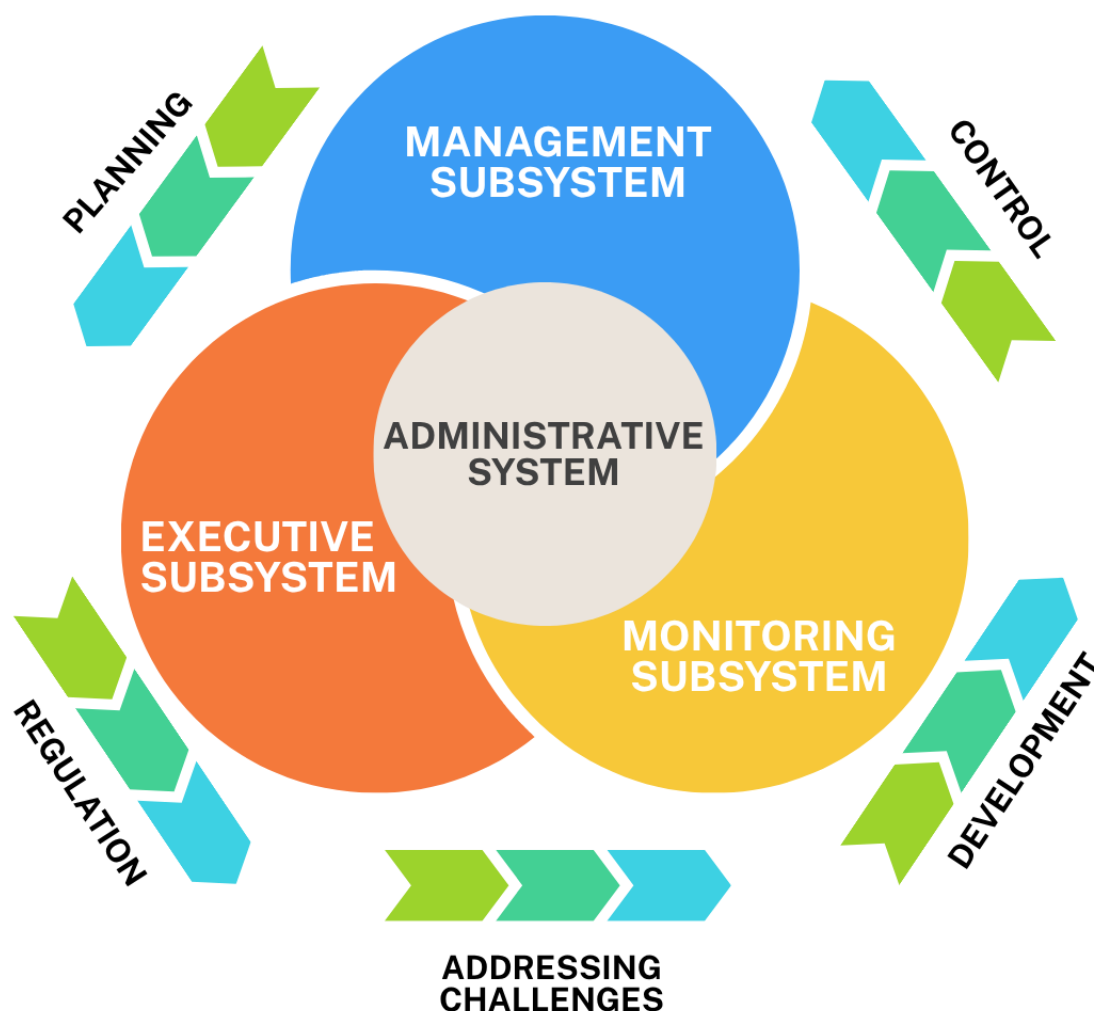


Fig. 2. Urban agglomeration governance system and its components (compiled by the author)

establishes the institutional foundations, and ensures a holistic vision of spatial transformation aligned with the principles of sustainable development. This subsystem functions as a generator of strategic decisions, coordinating the activities of various stakeholders and directing them toward achieving comprehensive sustainability goals. One of its core functions is the formulation of the conceptual basis for urban agglomeration development. This includes defining the mission, strategic priorities, tactical tasks, and operational objectives. The articulation of a development vision makes it possible to identify the desired future state of the agglomeration and guides inter-municipal strategic planning—especially relevant for agglomerations spanning multiple local governments or administrative-territorial units. In this context, the

managerial subsystem must ensure the integration of development goals across municipalities, alignment of sectoral strategies, and harmonization of spatial policies.

Its institutional foundation encompasses the establishment of urban agglomeration governance bodies, the development of cooperation frameworks between municipalities, financing mechanisms for joint projects, and the implementation of multilevel governance principles [41]. Strategic management must incorporate a participatory approach, involving community representatives, businesses, research institutions, and civil society organizations in the decision-making process. This aligns with SDG 16 regarding inclusive institutions, accountability, and participation. Another critical function is the integration of

sustainability principles at all levels of planning—from local socioeconomic development programs to master spatial plans. This requires balancing the three pillars of sustainability: economic viability, social equity, and environmental responsibility. The managerial subsystem must also be proactive and adaptive—able to anticipate external risks (economic, geopolitical, military, environmental, social, etc.) and develop mechanisms to adjust to them. This includes strategic foresight under uncertainty and scenario planning.

The executive subsystem is a core component of the governance system responsible for the practical implementation of strategic decisions, management programs, and regulatory mechanisms. Its primary purpose is to translate governance objectives into concrete actions, projects, and initiatives that ensure the viability, resilience, and balanced development of urban agglomerations [42]. It includes local governments and executive authorities functioning within the agglomeration—city and town councils, departments for territorial development, urban planning, transportation, public utilities, education, health care, and more. It may also involve intermunicipal structures or development agencies tasked with coordinating cooperation, territorial planning, resource distribution, and delegation of powers. Municipal enterprises, transport operators, education and healthcare institutions, and social service providers form an essential part of the executive system, delivering critical infrastructure and basic services [41].

The efficiency of this subsystem depends largely on coordination between its components, the degree of autonomy, availability of resources, and capacity for innovation. Digitalization plays an increasingly important role, including the use of data platforms, e-services, participatory tools, and mechanisms of e-governance. Given the spatial complexity of urban agglomerations, the executive system must enable multilevel governance that accounts for the specific needs of agglomeration cores, suburbs, satellite towns, and peripheral areas. In the post-war recovery context, its mandate includes not only crisis response but also ensuring long-term development in line with sustainability goals. This requires integrating social, economic, and environmental priorities; managing change flexibly; ensuring procedural transparency; and fostering openness to partnerships and new territorial governance models. Ultimately, the executive subsystem operationalizes governance strategies and policies and transforms vision into tangible urban transformations.

The monitoring subsystem is a dedicated functional unit designed to provide continuous observation, analysis, and evaluation of key processes occurring both within and around the agglomeration. It serves as a diagnostic tool for identifying positive

trends, threats, imbalances, and deviations from strategic objectives—thereby supporting management adaptability and informed decision-making [41]. This subsystem monitors all eight components of the internal agglomeration environment (social, economic, demographic, innovation-technological, architectural-construction, infrastructure-service, transport-logistics, and environmental) using key indicators of sustainable development and tracking the implementation of governance strategies. It also evaluates the influence of the external environment, including changes in legislation, investment climate, and geopolitical dynamics.

Core tools of this subsystem include GIS platforms, statistical databases, sociological surveys, and satellite imagery. The use of open data and e-governance tools ensures transparency and public accountability. Beyond merely tracking the current state, the monitoring subsystem must support scenario forecasting, risk assessment, and crisis prevention. Its role is to supply the managerial and executive subsystems with reliable, current, and structured information for decision-making, resource planning, strategy development, and policy adjustment.

Interactions between the three governance subsystems are complex, interdependent, and cyclical. The urban agglomeration governance system functions as an integrated structure comprising the managerial, executive, and monitoring subsystems. These interact in a systemic, cyclical, and adaptive manner, supporting the complete management cycle: planning, regulation, crisis response, development, and oversight [24].

The management subsystem handles long-term planning, defines the agglomeration's mission and vision, sets development priorities, identifies strategic growth zones, and shapes policy directions. It accounts for both internal needs and external challenges, including demographic shifts, security concerns, and labor market dynamics—especially relevant in the post-war recovery context. As part of its regulatory function, it formulates legal documents, concepts, and strategies that set the operational framework for executive bodies.

The executive subsystem implements strategies and policies through operational management, decision-making, and program execution. It coordinates all internal agglomeration subsystems, builds institutional mechanisms for development, and adapts governance tools to challenges, including emergencies and conflict. It manages internal processes such as resource mobilization, institutional coordination, and project delivery.

The monitoring subsystem conducts ongoing control, information collection and processing, and evaluation of implemented actions. It provides feedback to the strategic level, enabling plan and policy

adjustments. In a rapidly changing environment, it forms the basis for adaptive governance, enabling urban agglomerations to remain resilient to external influences and progress toward sustainability objectives [24, 41].

In our view, the external environment of an urban agglomeration must be differentiated by the type and intensity of influence across three hierarchical

levels—regional, national, and global—forming a complex field of exogenous factors. These include geopolitical conditions, security challenges, intergovernmental legislation, national and regional policy, climate change, cultural trends, migration flows, state subsidies, investment levels, and global technological shifts (Figure 3) [31, 54, 55].

The *regional level* of the external environment

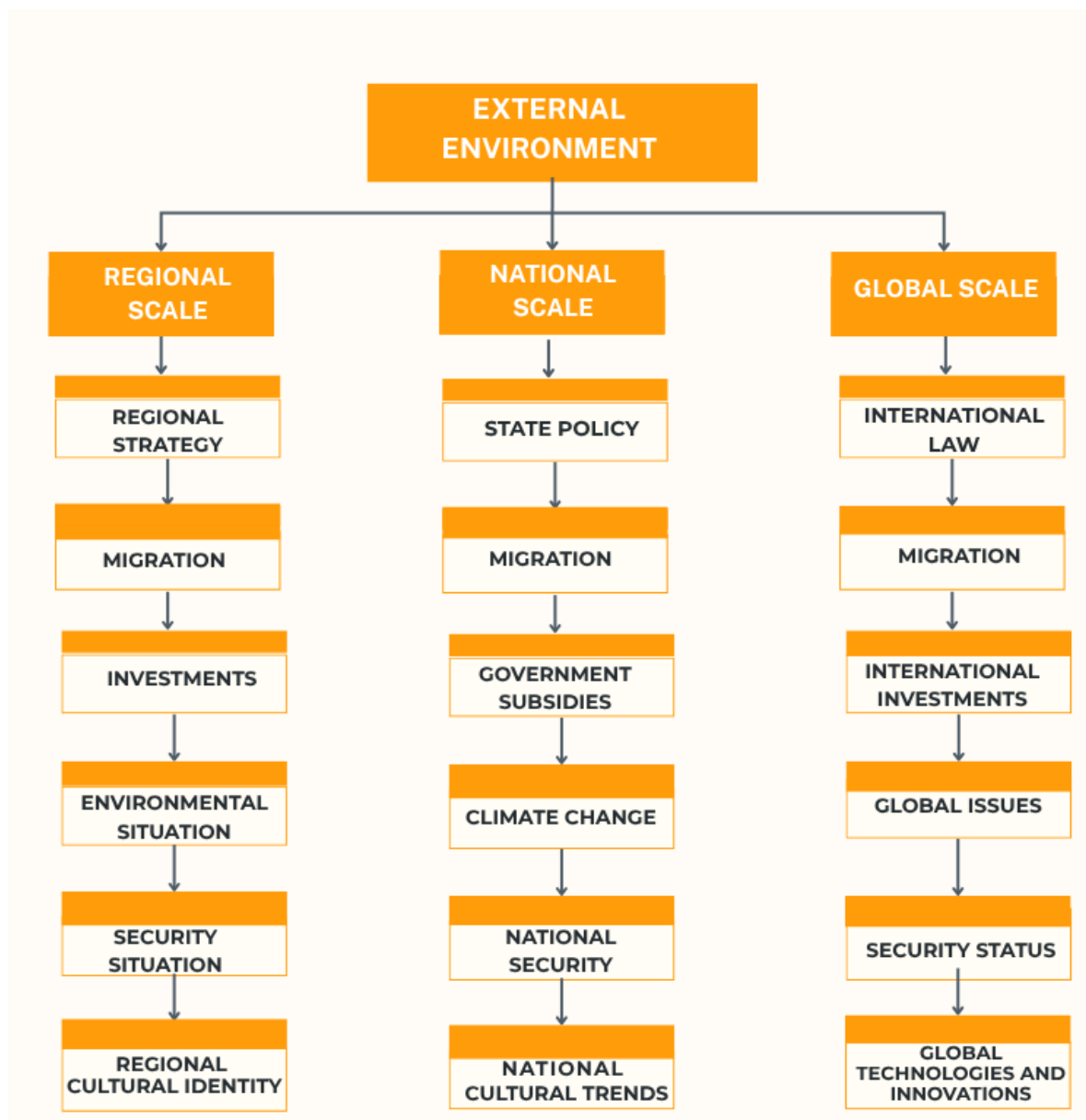


Fig. 3. Structure of the external environment of an urban agglomeration (compiled by the author)

of an urban agglomeration is a critical component of the multi-level system of external influences shaping the conditions for the functioning and development of urbanized territories. Within the proposed model, it is conceptualized as the foundational hierarchical tier in analyzing urban agglomerations, directly interacting with the internal environment and determining the spatial, socio-economic, ecological, and cultural dynamics of development. At this level, both relatively stable political and strategic contexts and high-

frequency adaptive responses to local and global challenges are recorded. Six key influencing elements are distinguished within this structure.

Regional policy serves as a fundamental instrument for shaping development trajectories in accordance with spatial planning priorities and strategic management goals. It encompasses tools such as territorial marketing, program-targeted planning, spatial zoning, and inter-municipal cooperation—providing the basis for a comprehensive urban policy. The regi-

onal level is responsible for balancing spatial development, coordinating the functional roles of the agglomeration core and peripheral municipalities, and implementing integrated development projects [41].

Commuter migration is the second key element, which reaches its greatest scale and impact within agglomeration systems. It refers to the daily movement of population between the core and suburban areas for work, education, and access to services. This process indicates the degree of spatial integration within the agglomeration and imposes strain on the transport and logistics subsystem, the environment, and social infrastructure. Addressing commuter migration requires regional planning of transit routes, optimization of public transport logistics, improvement of accessibility for remote areas, and balance in the territorial division of labor.

Investment, as the third component, plays a decisive role in stimulating economic growth within agglomerations. This includes not only financial inflows into infrastructure or entrepreneurship, but also institutional support for innovation clusters, development of technology parks, and creation of favorable conditions to enhance territorial investment attractiveness. The regulatory function of this dimension involves coordinating state, municipal, and private resources within regional development programs [4].

Environmental conditions, the fourth element, become especially pressing in agglomerated spaces due to the high concentration of population and economic activity. Environmental stress manifests in air pollution, declining water quality, soil degradation, and a shortage of green spaces. At the regional level, environmental policy is shaped, ecological monitoring is conducted, and restoration programs are implemented—thus laying the foundation for the environmental dimension of urban agglomeration sustainability.

Security, the fifth structural element, encompasses a broad range of challenges at the regional level—from public safety to emergency preparedness and response to technological and natural hazards. Its relevance increases under conditions of martial law, natural disasters, or social crises. Regional authorities coordinate civil protection, evacuation planning, critical infrastructure resilience, and public awareness initiatives.

Regional cultural identity provides the mental, symbolic, and communicative foundation for spatial development. It encompasses traditions, customs, forms of cultural expression, language, historical heritage, architectural style, and characteristics of civic life. Regional identity manifests in territorial branding, agglomeration image-building, support for cultural initiatives, and development of creative industries [10]. It also contributes to maintaining social cohesion and cultivating a sense of belonging.

The *national level* of the external environment plays a systemic role in enabling the functioning and development of urban agglomerations. It provides the regulatory, institutional, demographic, economic, and security frameworks. This level integrates national strategic policy priorities with local realities, acting as an intermediary between global processes and regional challenges. It is critical for synchronizing spatial development within agglomerations with national sustainable development goals [22].

A primary element of the national level is state policy, which defines the overall principles, approaches, and mechanisms for regulating urbanization processes, managing territorial development, spatial planning, and decentralization. Through legislative initiatives, regional development strategies, master plans, standards, and national programs, the state establishes the legal framework for agglomeration functioning. The implementation of concepts for integrated territorial development and the adoption of legislation on agglomerations or urban districts reflect efforts to systematize the country's spatial organization.

Internal migration is another key factor that shapes the socio-demographic structure of urban agglomerations. In Ukraine, this process has intensified due to military conflict, resulting in large-scale population displacement both across the country and within specific urbanized areas. Internal migration alters the burden on social infrastructure, housing, and labor markets, while influencing the demographic resilience of both the agglomeration core and periphery. During crises, the state acts as a regulator and guarantor of social protection, developing policies for internally displaced persons (IDPs) to ensure their housing, service access, and employment [26].

Another key component is state subsidies and grants, which serve as financial instruments for stimulating the development of urban agglomerations. Through mechanisms of budget equalization, state subventions, infrastructure grants, concessional loans, and public-private partnerships, the state can support large-scale projects in the areas of transportation, energy, education, and healthcare. Notably, national support programs have enabled initiatives on energy efficiency, infrastructure modernization, and digital transformation of cities. In the post-war period, targeted financing for the reconstruction of damaged areas has become a pressing issue. Climate change is increasingly being integrated into national strategies and plans. Urban agglomerations, as centers of anthropogenic pressure, are vulnerable to the effects of climate change—extreme weather, flooding, declining air quality, and more. In this context, the state performs a coordinating function in implementing climate adaptation principles, promoting green technologies, advancing sustainable mobility, transi-

tioning to energy-efficient construction, and reducing the carbon footprint of cities.

National security in the current context encompasses not only military but also social, energy, and digital dimensions. For urban agglomerations, this implies ensuring the resilience of life-support systems, protecting critical infrastructure, maintaining information security, preparing for epidemiological threats, and defending against cyberattacks. National programs for digital transformation, cybersecurity, and civil protection serve as the foundation for enhancing the resilience of urbanized territories [31].

National cultural trends shape the broader sociocultural context for the development of urban agglomerations. These include growing societal demands for comfortable urban environments, inclusivity, creative spaces, and civic participation in urban development decision-making. Shifts in value orientations affect urban planning approaches, architectural design, and policies in culture, heritage, and leisure—critical for building sustainable, attractive, and competitive agglomerations.

The *global level* of the external environment is a vital component of the exogenous influences on the functioning and development of urban agglomerations. It encompasses transnational processes, trends, and challenges that transcend national borders yet have direct impacts on urbanized territories through economic, legal, environmental, technological, and social channels. In a globalized world, urban agglomerations increasingly operate as elements of a global urban system, shaped by planetary changes and institutional frameworks.

A key global influence is international law, which sets the framework for cooperation among states, cities, and regions on issues such as sustainable development, climate commitments, human rights, migration, urban governance, and security [11]. Through participation in international conventions, charters, and agreements—such as the Paris Climate Agreement, the UN New Urban Agenda, and the Leipzig Charter—states commit to obligations that are subsequently implemented at the urban and regional levels, forming the legal foundation for agglomeration development strategies. The concept of sustainable development is a cornerstone of international law in the urban context, ensuring the integration of social, economic, and environmental dimensions. This is achieved through the application of sustainability indicators (e.g., service accessibility, environmental quality, mobility), localization of global goals in urban policies, and active engagement of agglomerations in international partnerships [40].

International migration acts as a powerful demographic and sociocultural force. Global crises, wars, climate change, and economic inequality drive population movements that transform the social compo-

sition of urban agglomerations, create multicultural communities, and necessitate inclusive infrastructure, adaptation policies, and multilingual services. Urban agglomerations serve as “magnets” for global migration flows, while simultaneously facing challenges of segregation, infrastructure stress, and shifts in social dynamics.

International investment increasingly flows into urban development projects such as infrastructure, construction, digitalization, innovation hubs, waste management, and green energy. Openness to transnational capital enables agglomerations to modernize subsystems, adopt new technologies, create jobs, and strengthen economic capacity. However, it also carries risks such as dependency on external financing, rising inequality, and commercialization of urban spaces.

Global risks—including pandemics, wars, food insecurity, energy crises, and technological disruption—often manifest as sudden shocks to urban systems. Urban agglomerations are therefore compelled to develop mechanisms of strategic resilience, build reserves, establish early-warning systems, and adapt to new patterns of work, mobility, and social behavior. In response, global solidarity networks such as ICLEI and C40 Cities are emerging, promoting knowledge exchange and collective action.

Global security, in this context, includes geopolitical instability, military conflicts, terrorism, and cyber threats—all of which directly affect the stability of agglomerations. At the same time, global technologies and innovations – including artificial intelligence, smart systems, blockchain, autonomous transport, and environmental monitoring – are transforming urban economies, governance, communication, and mobility. The integration of global technological solutions allows urban agglomerations to effectively respond to 21st-century challenges, improve quality of life, and enhance global competitiveness.

Based on the research findings, a structural model of an urban agglomeration as a functional component of the socio-geosystem is proposed (Fig. 4).

The presented model of an urban agglomeration as a functional component of a socio-geosystem outlines five key types of connections that ensure interaction between its internal subsystems and the external environment. These connections reflect the complex systemic dynamics of the agglomeration, its adaptability, openness, and capacity for transformation under the influence of multi-level factors. Intrasystem connections ensure the integrity and functional unity of the urban agglomeration [41]. They link the eight core subsystems (social, economic, demographic, innovation-technological, architectural-construction, infrastructure-service, transport-logistics, and natural-ecological), facilitating their interaction, interdependence, and coordinated operation.

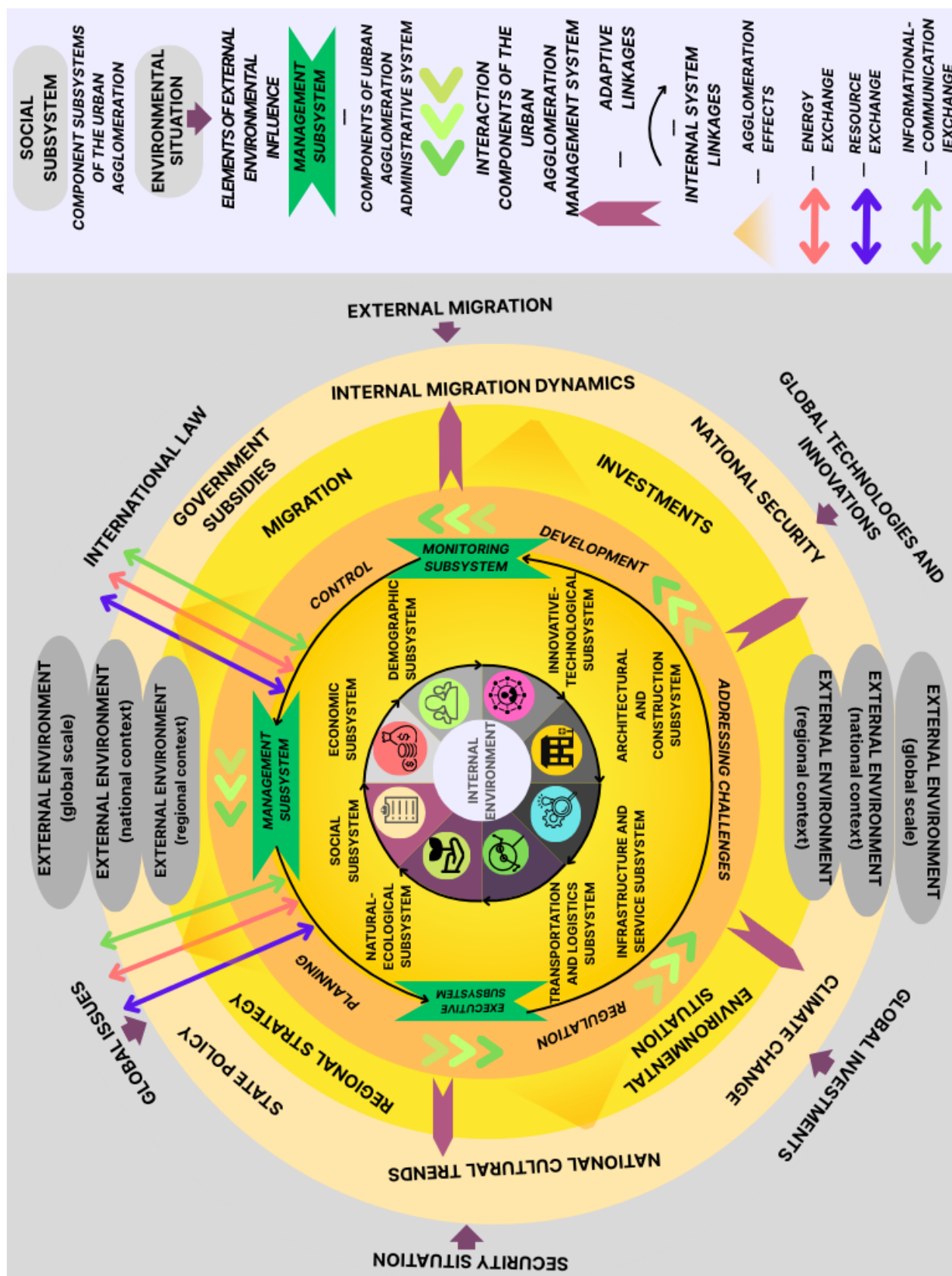


Fig. 4. Structural Model of the Urban Agglomeration as a Functional Component of the Socio-Geosystem (compiled by the author)

These connections encompass material, informational, and managerial flows, enabling the agglomeration to function as a self-regulating system. Adaptive connections link the management system with external environmental elements. They act as feedback mechanisms through which the system receives information on external changes (economic, political, environmental, social) and adjusts internal processes accordingly. Through such connections, the agglomeration remains resilient to external challenges, maintains its coherence, and ensures effective functioning even under crisis conditions [41]. Energy exchange refers to the flow of energy resources between the urban agglomeration and the external environment, including electricity, heat, and fuel supply, as well as optimization of energy use within the agglomeration. This exchange is critical for the sustainable functioning of infrastructure, transport, and production systems, and for the implementation of energy efficiency practices. Resource exchange represents the flow of material resources required to support the life of the urban agglomeration, its infrastructure, and services. This type of exchange also enables the agglomeration to act as either a donor or a recipient of resources within interterritorial networks. Information and communication exchange encompasses the transfer of knowledge, digital data, managerial and expert information, including innovation transfer, partnership communications, and participation in digital platforms and networks. This type of connection defines the intellectual and innovation potential of the agglomeration and its capacity to integrate into global information flows [41, 42]. A special role in the proposed scheme is played by agglomeration effects, which highlight the advantages of spatial concentration of population and activities—such as increased productivity, economies of scale, simplified access to labor markets, intensified innovation, and enhanced investment attractiveness. These effects strengthen the internal interaction of subsystems and also influence the agglomeration's external relations.

Discussion and Conclusions. This study proposes an analytical approach to urban agglomerations as complex, multi-level, and open organized socio-geosystems that function in dynamic interaction with the external environment and are characterized by a high degree of internal integration and adaptability. The author's structural model of the urban agglomeration presents it not merely as a spatial formation, but

as a functional system in which eight internal subsystems (social, economic, demographic, innovation-technological, architectural-construction, infrastructure-service, transport-logistics, and natural-ecological) play a central role. Their interaction forms the foundation for stability, development, and governance.

Each subsystem performs autonomous functions and acts as a component of an integrated synergistic complex, which gives rise to the agglomeration's emergent properties—its ability for self-regulation, adaptation, and development under internal and external challenges. A critical element in ensuring the system's functional integrity is the governance subsystem, comprising managerial, executive, and monitoring components. This subsystem performs planning, regulation, crisis response, sustainability maintenance, and control over developmental dynamics. An important contribution of the study is the analysis of the multi-level structure of the external environment in which the urban agglomeration operates. Regional, national, and global levels generate distinct vectors of influence, including regulatory policies, economic trends, security challenges, migration processes, cultural drivers, global technological shifts, and institutional frameworks. This multi-dimensional external landscape must be considered in agglomeration governance, particularly in the context of transitioning to a sustainable development model. The proposed model has both theoretical and practical significance. It can serve as a conceptual foundation for strategic planning of urban agglomeration development, municipal policy formation, the creation of monitoring tools, and governance systems oriented toward achieving the Sustainable Development Goals (SDGs). This framework enables the integration of spatial, functional, social, environmental, and managerial dimensions within a single system, which is particularly relevant for Ukrainian agglomerations amid post-war reconstruction, decentralization, and shifting territorial configurations. Future research should focus on developing empirical methods for quantitatively assessing types of interactions within agglomerations, establishing sustainability indicators, and adapting the model to the specifics of individual urbanized systems in Ukraine, taking into account available resources and contextual challenges.

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Міська агломерація: суспільно-географічна концепція в перспективі сталого розвитку

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Міські агломерації виступають складними відкритими просторово-функціональними системами, що відіграють ключову роль у соціально-економічному розвитку регіонів та країн, забезпеченні стійкості в умовах глобальних трансформацій. В умовах війни в Україні міські агломерації зазнали значного впливу, деякі трансформувались у центри прийняття внутрішньо переміщених осіб, логістичні хаби та простори опору, що зумовлює потребу у новому підході до їхнього дослідження, планування та управління їх розвитком. Метою дослідження є формування суспільно-географічної концепції міської агломерації як підсистеми соціогеосистеми, побудова авторської моделі її функціонування у взаємодії з зовнішнім середовищем та обґрунтування потенціалу сталого розвитку. У статті представлено авторську структурну модель міської агломерації як ієрархічної, динамічної системи, що включає вісім функціональних підсистем: соціальну, економічну, демографічну, інноваційно-технологічну, архітектурно-будівельну, інфраструктурно-обслуговуючу, транспортно-логістичну та природно-екологічну. Розкрито їх взаємодію, синергетичні властивості та значення для просторової єдності агломерації. Особлива увага приділена системі управління міською агломерацією, що включає керуючу, виконавчу та моніторингову підсистеми, які забезпечують адаптацію до зовнішніх викликів, реалізацію управлінських рішень та контроль за динамікою розвитку міської агломерації. Охарактеризовано три рівні зовнішнього середовища (регіональний, національний, глобальний), які здійснюють політичний, правовий, екологічний, демографічний, культурний і технологічний вплив на функціонування міської агломерації. Виокремлено п'ять типів зв'язків, що забезпечують взаємодію підсистем: внутрішньосистемні, адаптаційні, енергетичні, ресурсні та інформаційно-комунікаційні. Запропонована модель дозволяє комплексно оцінити потенціал міських агломерацій у контексті сталого розвитку, зокрема в умовах повоєнного відновлення України, та є практичним інструментом стратегічного планування і моніторингу.

Ключові слова: міська агломерація, соціогеосистема, сталий розвиток, управління, адаптивність, зовнішнє середовище.

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