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IMPLEMENTATION OF INTEGRATED MODELS OF STRATEGIC MANAGEMENT FOR SMART CITIES

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The article advances the theoretical and methodological foundations of strategic management for smart cities under conditions of digital transformation, climate challenges, post-war recovery and growing requirements for the quality, accessibility and resilience of urban services. The purpose of the study is to substantiate a polycentric adaptive-integrated model of strategic management for a smart city, which combines strategic planning, data interoperability, digital platforms, sustainable urban services and social impact assessment within a single governance architecture. The methodological framework is based on systemic, institutional, comparative, structural-functional and case-oriented approaches. This made it possible to generalize international and Ukrainian experience in smart governance, the use of the Internet of Things, cloud services, big data, digital platforms, environmentally friendly mobility, smart energy grids and modern waste management systems. The scientific novelty of the study lies in the development of the author's polycentric adaptive-integrated model, which aligns goals, actors, data, services, investments and quality-of-life indicators and can be applied to cities of different sizes and levels of digital maturity. The model focuses not only on the introduction of technologies, but also on their integration into strategic decision-making, intersectoral coordination, public participation and measurable public value. The practical significance of the results lies in the possibility of using the proposed model for preparing municipal digital transformation strategies, recovery plans, climate neutrality programs, smart city development roadmaps, and systems for assessing the digital maturity and resilience of urban communities.

Keywords: smart city, strategic management, smart governance, digital platforms, Internet of Things, big data, energy efficiency, quality of life.

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Introduction and Problem Statement

The war, which has now been ongoing for several years, has made us acutely aware of the need to introduce "smart technologies" into our lives. Urban residents and internally displaced persons are facing an increasing number of challenges. Particularly relevant are issues of population mobility, improving energy efficiency, life safety, barrier-free access, infrastructure accessibility, especially for large numbers of people with disabilities, and easy access to administrative services.

The implementation of "smart" technologies in today's new realities is becoming increasingly relevant. These technologies can help ensure public safety and provide effective interaction and service delivery remotely. In general, the idea of a "smart" city is simple: it is a place where people can live safely and comfortably, where the business ecosystem has favorable conditions for development, and where municipal authorities operate transparently and efficiently. Therefore, the importance of this issue is considerable.

Today, a smart city is no longer merely an idea associated with technology. It is becoming a practical instrument of strategic management that requires the alignment of digital infrastructure, human capital, institutional capacity, and environmental performance. For Ukraine, this topic is of dual importance. On the one hand, digital tools have already become the foundation of state and local services; on the other hand, post-war recovery requires the formation of urban development models that simultaneously ensure resilience, energy efficiency, transparency, and the rapid scaling of innovations.

Despite numerous studies and practical initiatives, in most municipalities digital solutions are still implemented in a fragmented manner: transport is modernized separately, energy systems separately, and urban platforms or open analytics separately. As a result, no unified system is formed in which data are transformed into strategic decisions, and strategic decisions into measurable social impact. It is precisely this gap between technology, governance, and outcomes that determines the relevance of studying integrated models of strategic management for smart cities.

Analysis of Publications and Previous Research

In contemporary smart city studies, a growing shift can be observed away from a purely technological understanding of this concept. Whereas smart cities were previously associated mainly with digital solutions, sensors, platforms, and automation, today the emphasis is increasingly placed on governance, coordination, data use, stakeholder participation, and the real impact on quality of life. This is emphasized by L. Mora, P. Gerli, L. Ardito, and A. Messeni Petruzzelli, who demonstrate that digital innovations alone do not generate systemic effects unless they are embedded in an appropriate urban governance architecture [6]. In the same vein, the OECD highlights data as a strategic urban resource, C. Yang and co-authors stress the importance of platform-based interaction across sectors, and recent studies on digital twins and urban resilience point to the significance of analytics, forecasting, and adaptive response [1, 8, 12]. All this indicates that today the smart city is increasingly viewed not simply as a set of technologies, but as a holistic system of strategic management.

At the same time, for a more comprehensive understanding of this issue, it is important to consider not only the international theoretical discourse, but also Ukrainian publications reflecting domestic experience, real practices, and the specific development of cities under conditions of war and recovery. Thus, the paper "Global Smart Trends in the Development of 'Smart Cities' and Ukrainian Realities" shows how global trends in the field of smart cities are gradually being implemented in Ukrainian communities. The authors draw attention to the implementation of IoT solutions, the digitalization of transport, smart metering, and, more broadly, the transition of cities toward more systemic, data-driven governance [5]. The publication "Smart Transformation of Cities: Safer and More Comfortable" focuses primarily on the practical importance of smart solutions for safety, residents' comfort, transparency of municipal governance, and supporting urban functioning under wartime challenges [7]. The article by L. I. Tsymbal and I. M. Uninets is more analytical in nature: it examines the level of smart city development in Ukraine, demonstrates the unevenness of their digital maturity, and outlines the main trends and barriers to the further implementation of smart solutions [13]. The work of Yu. A. Romanovska is important because it reveals the European context of smart city development, where the priorities are not only technological advancement, but also environmental sustainability, resilience, inclusiveness, and cities' ability to adapt to new conditions [12]. In turn, the study by O. L. Yershova and L. I. Bazhan systematizes the basic theoretical foundations of the smart city concept, including its models, key technological components, and the role of standardization as an important condition for the compatibility of urban systems and the further scaling of digital solutions [9].

Thus, the synthesis of both international and Ukrainian publications makes it possible to better understand the contemporary logic of smart city development. While foreign authors provide a broad theoretical framework centered on governance, data, platformization, and strategic coordination, Ukrainian sources fill this framework with concrete content related to the digital transformation of communities, the unevenness of local capacity, security challenges, and the needs of post-war recovery. It is precisely the combination of these two dimensions – international theory and Ukrainian practice – that creates a proper foundation for substantiating an integrated model of strategic management for a smart city. To strengthen the evidential basis of the scientific novelty, it is advisable to summarize the differences between existing approaches and the author's model in the form of a comparative matrix (Table 1).

The comparative matrix presented above shows that the proposed author's model does not duplicate existing concepts, but rather integrates their strongest elements into a unified polycentric adaptive-integrated architecture of strategic management. This creates the basis for moving from a review-based analysis of smart city approaches to the substantiation of the author's own model, its methodological logic, and its applied potential. At the same time, the comparative matrix makes it possible to define more clearly that the scientific contribution of the article lies not in a mechanical combination of already known components, but in the formation of a coherent model in which external challenges, the composition of actors, functional contours, the adaptive cycle, and multilevel outcomes are integrated into a single system of strategic governance.

Table 1

Comparative Matrix of Existing Approaches and the Author's Model of Strategic Management for a Smart City

Approach / Authors	Main Focus	Limitations of the Approach	What the Author's Model Adds
Mora et al.	Innovative and managerial architecture of the city; the role of governance in the smart city.	The integration of the external environment, performance outcomes, and the adaptation cycle is not sufficiently detailed.	It combines the governance architecture with external challenges, a polycentric composition of actors, an adaptive cycle, and multilevel outcomes.
Almulhim, Yigitcanlar	A multidimensional framework of smart governance covering institutions, participation, sustainability, and data..	The approach outlines the dimensions of smart governance, but provides an operational scheme of strategic management to a lesser extent.	It offers not only a dimensional framework, but also a comprehensive strategic management scheme with governance contours, KPIs, ervices, platforms, and the assessment of social value.
OECD	Data governance; data as a strategic asset of the city.	The main emphasis is placed on data governance, without sufficient linkage to the service and investment contours of urban development.	It integrates data governance with platform-based coordination, service implementation, investment priorities, and the assessment of quality of life.
Yang et al.	Platform-based synergy across sectors; digital platforms as a coordination mechanism.	The role of the external environment, the composition of actors, and the adaptive decision-making cycle is insufficiently disclosed.	It considers the platform contour as part of a broader polycentric model, in which platforms are linked to data, services, strategy, and outcomes.
Digital Twin / Urban Resilience Approaches	Forecasting, scenario analysis, digital twins, and the resilience of urban systems.	They are mainly focused on analytical and forecasting functions, without a holistic integration of governance and social value.	It combines scenario-based planning and digital twins with polycentric governance, strategic priorities, and the assessment of trust, quality of life, and resilience.
Author's Model	Polycentric adaptive-integrated architecture: external environment, actors, four functional contours, adaptive cycle, and multilevel outcomes.	–	It systematically combines social value, data interoperability, platform-based coordination, service implementation, impact assessment, and applicability for cities undergoing modernization and recovery.

Source: compiled by the author based on [1, 5, 6].

Purpose of the Article

The purpose of the article is to examine the advantages of the smart city concept and to substantiate a polycentric adaptive-integrated model of strategic management for a smart city, developed on the basis of a step-by-step synthesis of external challenges of urban development, corresponding governance contours, and expected outcomes. The proposed model combines the influence of the external environment, the interaction of the main actors of urban development, the strategic, data-interoperability, service, and platform governance contours, as well as an adaptive decision-making cycle and a system for evaluating results through the categories of social value, quality of life, resilience, and trust. To achieve this purpose, the study предусматривает defining the essence of the "smart city" and refining the conceptual apparatus of smart governance, comparing the author's model with existing theoretical approaches, systematizing global and Ukrainian experience across key governance contours, specifying the procedures for model formation, and outlining a minimum set of indicators for its practical application.

Presentation of the Main Material

The continuous growth of the world's population, the increasing number of vehicles on the roads, the inefficient use of land resources, and the destruction of natural resources, forests, parks, and meadows all undermine the conditions for normal human existence and lead to significant disruptions and destructive processes. In large cities, serious problems arise due to the high level of air, river, and soil pollution caused by the concentration of vehicles, as well as enterprises that pollute the air and the environment.

In the future, megacities will become even more complex systems, the management of which will be practically impossible without modern technological solutions. The concept of the "smart city" is becoming increasingly relevant every day. At present, around 2,500 cities worldwide are engaged with this concept, although each is doing so in its own way. Some propose building such cities from scratch, while most are gradually introducing smart city instruments [11]. The benefits of smart technologies in cities are beyond doubt, and the main goal is to improve the quality of life of the population through digitalization.

So, what are the advantages of a "smart city"? They include convenience, comfort, safety, reliability, efficiency, and new opportunities (Table 2).

Table 2

Advantages of a "Smart City" in Modern Living Conditions

Advantages of a "Smart City"	
Safety of life	Digital technologies help create a safer living environment for residents. For example, AI-based systems can analyze weather data, such as wind speed and humidity, to predict how many residents may fall ill during a given month. They also contribute to energy savings and improve safety in streets, public spaces, and institutions through monitoring systems. In addition, intelligent video surveillance applications help reduce crime rates and support traffic monitoring.
Infrastructure and Governance Efficiency	IoT (Internet of Things) systems make it possible to monitor water and electricity consumption, as well as the fill levels of waste containers, thereby optimizing the work of municipal services. Digital platforms support the management of "smart stations," intelligent transport systems, and improve the operation of public services, hospitals, and other institutions.
Comfort and Sustainable Development	Equipping the city with sensors and cameras makes it possible to measure air quality, noise levels, temperature, water levels in streets and drainage systems, and other indicators, and to use these data for implementing "smart" solutions. Even an "iron dome," in addition to providing protection from shelling, can contribute to better living conditions for the population by helping regulate air temperature and creating more comfortable conditions in cases of dryness or humidity.
Mobility	The implementation of artificial intelligence-based systems can be used to monitor road conditions in real time. This makes it possible to optimize traffic flow and help reduce congestion, as well as to inform city residents about road conditions for better navigation. Such systems can reduce the risk of road accidents, allow people to adjust their routes, and help them arrive at their destination on time
Increased Trust in Government	With the help of digital technologies, communication between the public and local institutions develops more rapidly. These technologies make it possible to inform the public in a timely manner, promptly collect information about urban problems and needs, and engage residents in voting and selecting projects aimed at improving city life. This contributes to stronger social ties and greater public involvement in urban processes.

Source: compiled by the author based on [5, 7].

Smart governance should be understood as a data-driven, polycentric, and value-oriented type of strategic governance in which city authorities, municipal operators, businesses, research institutions, and residents jointly shape decisions on the basis of digital evidence, scenario analysis, and regular measurement of outcomes. Unlike the traditional administrative model, where decisions are often made reactively and in isolation, smart governance presupposes a continuous cycle of "data collection –

analysis – decision-making – effect verification – policy adjustment.” That is why the OECD considers data to be a strategic asset of the city rather than a technical add-on to individual services [2].

Global experience shows that successful smart cities are moving away from the perception of a smart city as merely a set of sensors and applications. In Singapore, the Smart Nation 2.0 model links digitalization not only with service efficiency, but also with trust, inclusion, skills, and the safe use of data. In European cities such as Barcelona, Vienna, and Amsterdam, the emphasis is shifting toward openness, interoperability, and the integration of digital solutions with climate policy. Significantly, in 2025 the IMD assessed a city’s “smartness” not only by its technological intensity, but also by humanistic dimensions such as quality of life, accessibility of services, inclusiveness, and environmental conditions. This means that the concept of smart governance is objectively expanding into the concept of governance for public value.

In Ukraine, this logic is already reflected in practice. In 2025, more than 23 million people used the Diia service, representing 77% of all smartphone owners in the country [11]. At the municipal level, the Kyiv Digital platform reached 3.3 million users in 2024, collected 15 million votes in public polls, and enabled 270 million validations in public transport [10]. These data indicate that Ukrainian cities already have an empirical basis for moving from electronic service delivery to data-driven urban governance. However, this basis has not yet been fully integrated everywhere into strategic planning, budgeting, and KPI systems.

Thus, the content of the smart governance concept includes at least five interrelated elements: the digital identity of urban processes; institutional coordination across sectors; the integration of data into strategic planning; citizen participation through digital channels; and the measurement not only of operational efficiency, but also of the ultimate impact on quality of life. Without these elements, a smart city remains a set of separate projects rather than a model of strategic development.

Moving from the substantive understanding of smart governance to its applied architecture, it should be noted that an integrated model of strategic management for a smart city must be based on the principles of systemicity, interoperability, adaptability, polycentricity, human-centeredness, and measurability of results. Systemicity means that transport, energy, ecology, security, housing and communal services, and digital participation are considered not in isolation, but as interdependent contours of the urban ecosystem. Interoperability ensures the shared use of data, standards, and registers; adaptability enables the rapid adjustment of decisions in times of crisis; polycentricity implies the distribution of roles among authorities, infrastructure operators, businesses, and the community; human-centeredness prioritizes public value; and measurability links all actions to KPIs and impact indicators.

Based on the generalization of global experience, it is advisable to distinguish the following components of an integrated model: a) the strategic contour, which defines goals, scenarios, and investment priorities; b) the data and interoperability contour, which includes IoT, registers, geodata, cloud services, and data exchange standards; c) the service contour, where digital solutions are applied in transport, energy, waste management, security, and social services; d) the platform contour, which ensures service integration, citizen participation, APIs, and open data; e) the impact assessment contour, which captures changes in emissions, mobility, energy consumption, service accessibility, and residents’ satisfaction. It is precisely the presence of this last contour that is most often lacking in urban practice.

The Ukrainian context adds one more mandatory component – the resilience and recovery contour. For cities operating under wartime risks and limited resources, the smart city should be not only an instrument of modernization, but also a mechanism for prioritizing recovery. This means that the integrated model must answer the following questions: which data are critically important for service continuity; which services should be transferred to backup or cloud-based solutions; and which investments generate the greatest simultaneous environmental, social, and governance effects. In this respect, Ukrainian cities may be regarded as an environment for testing resilient models of smart governance adapted to the conditions of recovery and resource constraints.

The practical implementation of the outlined principles is impossible without a developed technological infrastructure, and above all without the Internet of Things, which forms the sensory layer of the smart city and enables governance to move from periodic reporting to continuous monitoring and forecasting. This includes traffic sensors, energy meters, air quality sensors, water monitoring systems, lighting systems, container fill-level sensors, parking systems, public safety systems, and infrastructure condition monitoring. The global basis for scaling IoT is rapidly expanding: according to the ITU, in 2025, 5G covers 55% of the world’s population, while networks of at least 3G cover 96% of the population [4]. This significantly increases the technical possibilities for collecting urban data in real time.

In global practice, IoT delivers the most tangible effect where the collected data are directly embedded into decision-making regulations. In Singapore, sensor-based solutions are integrated with transport, environmental, and security platforms; in Barcelona, the development of a digital twin and analytical dashboards is used for mobility modeling and spatial planning; and within the European Local Digital Twin Toolbox initiative, digital twins are viewed as a way to connect geodata, IoT, and policy modeling within a single working environment [1]. The key lesson is that cities benefit not from the number of sensors, but from their ability to transform data flows into action.

Ukrainian experience also demonstrates the gradual accumulation of IoT practices. The most notable examples include transport validation systems, video analytics, public transport monitoring, smart lighting, remote energy metering, and digital dispatching systems. A representative example is Kyiv, where 270 million transport validations were recorded through the Kyiv Digital platform in 2024 [10]. This is not only service statistics, but also a powerful dataset for analyzing route behavior, infrastructure load, peak travel times, and planning new transport solutions.

The prospects for IoT use in Ukraine are primarily associated with the development of local digital twins, smart energy metering, sensor-based monitoring of critical infrastructure, and urban ecology. This requires not only equipment procurement, but above all data standards, secure communication channels, API architecture, and regulations for the use of data in managerial decision-making. Only then does IoT become not merely a technical element, but a foundation for strategic management.

Thus, the analysis of IoT practices shows that the strategic value of sensor infrastructure is determined not by the number of sensors, but by the degree to which the data obtained are incorporated into planning, dispatching, investment prioritization, and preventive response procedures.

The next level of this infrastructure is formed by cloud services, which play the role of a basic digital foundation in a smart city by ensuring scalability, backup capacity, rapid service deployment, register integration, and continuity of access. They are especially important for cities that simultaneously work with large datasets, distributed teams, and critical services. European statistics confirm the fundamental nature of this technology: according to Eurostat, in 2025, 52.74% of EU enterprises used paid cloud services, while among large enterprises this figure reached 84.67% [15]. This trend shows that the cloud has become the new norm of digital governance rather than an optional solution.

In urban governance, cloud services ensure at least four effects. First, they make it possible to rapidly scale digital services without excessive capital expenditures on local infrastructure. Second, they enhance the resilience and continuity of urban platforms. Third, they simplify the analytical integration of various data sources, from IoT to registers and geographic information systems. Fourth, they create conditions for experimentation with digital twins, analytical dashboards, predictive models, and AI-based solutions. That is why, in the global smart city agenda, the cloud is increasingly regarded as an infrastructure of trust and resilience.

For Ukraine, the role of cloud solutions is even more important because of the security dimension. The digitalization of state and municipal services during wartime has demonstrated that cloud architectures make it possible to improve service accessibility, reduce dependence on individual physical server facilities, and accelerate product updates. At the state level, this was manifested in the scaling of Diia and related services; at the local level, in the transition of urban products to more flexible and resilient architectures. For cities, this means the need to develop not only a list of services, but also a strategy of cloud maturity: what should be transferred to the cloud, which data should be backed up, and which services should be prioritized for continuity.

A promising direction is the integration of cloud services with municipal data platforms and recovery analytics systems. For Ukrainian cities, this may mean creating unified data contours for infrastructure, finance, transport, waste management, and public participation. Under such conditions, the cloud ceases to be merely a technological solution and becomes a prerequisite for integrated strategic management.

Thus, in the author's model, cloud services are not a supplementary IT option, but an infrastructure of continuity and scalability, without which resilient municipal platforms, digital twins, and recovery analytics are impossible.

Big data represent a logical continuation of sensor and cloud infrastructure, as they are precisely what allow large volumes of information to be transformed into insights, forecasts, and managerial scenarios. In urban governance, this means the ability to predict traffic flows, identify areas of energy loss, optimize waste collection routes, analyze citizens' appeals, model demand for services, and assess the effectiveness of budget decisions.

According to Eurostat, in 2025, 39.85% of EU enterprises used data analytics either in-house or with the involvement of external contractors [15]. Although this figure refers not only to the urban sector, it demonstrates the general maturity of an environment in which analytics is becoming a standard management tool. Global smart city experience confirms that cities with a high level of platform integration are already moving from descriptive analytics to predictive and prescriptive analytics; that is, they do not merely record past phenomena, but forecast them and propose possible courses of action.

For Ukraine, Big Data are especially important in the context of recovery and more precise resource management. Examples of digital platforms show that the country is already generating significant volumes of transactional and behavioral data. In 2025, more than 23 million people used the Diia service [11], and Ukraine ranked fourth in Europe in terms of Open Data Maturity, with a score of 97.1% [14]. This means that a real foundation has been created for the transition from digital services to systematic urban analytics. At the same time, studies of local data transparency show that a gap still exists between national policy and municipal practice. Therefore, the key task is to strengthen the local capacity of cities to work with data.

Moving from technological infrastructure to the applied contours of sustainable development, mobility should be considered first, as it is one of the most visible dimensions of a smart city and directly affects emissions, air quality, travel time, service accessibility, and the subjective perception of quality of life. Integrated transport models of a smart city include the electrification of transport, digital route management, prioritization of public transport, micromobility, Mobility-as-a-Service (MaaS) platforms, parking analytics, and the use of real-time data for dispatching. According to the IEA, in 2024, global sales of electric vehicles exceeded 17 million units, and their share in total car sales exceeded 20% [3]. This confirms that the electrification of urban mobility is becoming a global rather than a niche process.

Summarizing the above, it can be argued that big data form the analytical core of the model: they are precisely what shift digitalization from the level of information accumulation to the level of forecasting, evaluating alternatives, and selecting strategic scenarios.

Global experience shows that the most effective approaches are not isolated electric mobility initiatives, but integrated policies. Since 2025, Amsterdam has introduced a zero-emission zone for urban logistics in the central part of the city; Singapore combines digital pricing with transport analytics; and in many European cities, electrification is combined with data on traffic, demand, and the use of public space. Their common feature is that transport is regarded not merely as a sector, but as an integrated part of climate and digital policy.

Ukraine is also demonstrating dynamic growth in electric mobility even under wartime conditions. According to Ukravtoprom, in 2025 the Ukrainian market for battery electric vehicles (BEVs) doubled, and the national fleet increased by more than 110 thousand electric vehicles, of which 107,470 were passenger cars [cf. the global trend, 3]. Although these statistics do not yet indicate a systemic transformation of urban mobility, they create the preconditions for the development of charging infrastructure, digital parking management, and new transport policies at the community level. For large cities, the next step should be the integration of data on validations, traffic, parking, public transport, and charging networks into a single transport management dashboard.

The prospects for Ukrainian cities lie in the transition from transport digitalization to mobility governance, where data on demand, travel time, emissions, and spatial equity are used for the strategic reallocation of investments. This is especially relevant during the recovery period, when decisions on new routes, transfer hubs, cycling infrastructure, and electric buses can be designed from the outset as smart and climate-compatible.

It follows that the transport contour should be assessed not only by traffic parameters, but also by its contribution to emission reduction, time accessibility, spatial equity, and integration with other urban services.

An equally important contour of a sustainable smart city is energy. The energy contour of a smart city includes not only generation and consumption, but also digital demand balancing, smart metering, controllable loads, building energy efficiency, local generation, and integration with climate plans. The IEA emphasizes that, to move onto a net-zero trajectory, global annual investment in power grids must increase from approximately USD 330 billion to USD 750 billion by 2030, with about 75% of these funds needed specifically for the expansion, strengthening, and digitalization of distribution networks [2]. Thus, the smart grid is not a supplementary element of the energy transition, but its infrastructural prerequisite.

In global practice, smart energy grids are combined with demand management systems, energy communities, local digital twins, and dynamic pricing platforms. Amsterdam, Copenhagen, Vienna, and a number of Scandinavian cities use smart grids not only to reduce losses, but also to integrate electric mobility, rooftop solar PV, heat pumps, and digital building management. This changes the very logic of urban energy planning: instead of increasing supply, the city optimizes demand, flexibility, and backup capacity.

For Ukraine, the digitalization of distribution networks has a dual effect: improving energy efficiency and strengthening resilience. According to Dixi Group, by the end of 2024, nearly 19.7% of household electricity consumers in Ukraine were using smart meters, and a total of 3.29 million such meters had been installed; in 2025, operators planned to install an additional 611.2 thousand meters [15]. This creates real preconditions for moving from simple metering to flexible demand management, targeted tariff incentives, digital loss detection, and more accurate municipal energy planning.

For Ukrainian cities, three directions are particularly promising. The first is the integration of smart metering and energy-efficient building modernization into unified demand management programs. The second is the combination of digital network monitoring with local generation and energy storage for critical infrastructure facilities. The third is the development of municipal energy platforms in which data on buildings, consumption, outages, and microgeneration are used for strategic investment planning. It is precisely this approach that shifts the smart grid from a technical innovation into the sphere of strategic urban management.

Thus, in the proposed model, the energy contour has not only a technological, but also a strategic dimension: it combines energy efficiency, the resilience of critical infrastructure, digital metering, and demand manageability.

Alongside transport and energy, the waste management system is another critical area for strategic governance, serving as a clear example of how a smart city combines physical infrastructure, behavioral change, data analytics, and environmental policy. Traditionally, waste has been treated as a municipal operation of collection and disposal. In a smart city, this logic changes: waste becomes a field of route optimization, container fill-level sensors, sorting analytics, extended producer responsibility, forecasting of material flows, and digital monitoring of environmental effects. According to the World Bank, billions of tons of municipal solid waste are generated globally every year, and under a business-as-usual scenario, their volume will continue to grow [14].

Global experience demonstrates that the best results are achieved when digital tools enhance not only waste collection, but also waste prevention, sorting, and the reuse of resources. In many European cities, container fill-level sensors are used to optimize collection routes, while data on waste morphology are used to plan sorting and composting infrastructure. Amsterdam, Copenhagen, Ljubljana, and a number of German cities show that smart waste management should function as part of a circular urban economy.

For Ukraine, this area is one of the most difficult, but at the same time one of the most promising. According to the EBRD, the country generates up to 13 million tons of municipal waste annually, while the recycling rate remains only in the range of 3-8% [15]. This means that the modernization of the waste system is not a narrowly environmental issue, but a strategic task of urban development. The problem of construction waste has also become particularly urgent, as its volume has increased significantly due to the destruction of housing and infrastructure. For Ukrainian cities, this creates the need for digital mapping of waste flows, route planning, environmental monitoring, and the planning of new infrastructure on the basis of data.

A promising model for Ukraine lies in the combination of sensor-based container monitoring, geoanalytics, platform-based interaction among carriers and recycling operators, as well as municipal information campaigns. In the context of post-war recovery, digitalization can help move from merely "patching up" an outdated system to creating a fully fledged circular infrastructure.

Thus, the waste sector demonstrates that effective smart governance emerges where digital tools support a circular logic rather than being limited to the automation of individual municipal operations.

The generalization of environmental, infrastructural, and service-related effects leads to the broader issue of performance, since the ultimate criterion for the success of a smart city is not the volume of technologies, but improvements in residents' quality of life. This concept encompasses the accessibility and speed of services, mobility, safety, air quality, energy comfort, inclusiveness, trust in institutions, and the ability of citizens to influence decisions. That is why the IMD Smart City Index considers technological solutions in connection with the human-centered dimensions of the urban environment [cf. global practice, 15]. For strategic management, this means that any smart project should be assessed through its impact on people's everyday experience.

Global experience shows that quality of life improves where smart solutions integrate several sectors simultaneously. For example, transport digitalization should be assessed not only by traffic speed, but also by emission reductions and improved accessibility. Energy solutions should be evaluated not only by savings, but also by comfort and resilience during crises.

Digital platforms should be measured not only by the number of downloads, but also by the real capacity of citizens to solve problems without additional barriers.

In Ukraine, there are already important empirical signals of such an approach. According to the results of 2024, 84% of users of state e-services assessed their experience as rather or very positive [11]; at the same time, Kyiv Digital demonstrated a high level of resident engagement in surveys, voting, and transport services [10]. However, for most cities, the main problem lies in the absence of a system that links these service indicators with broader measures of well-being, trust, inclusion, and resilience.

Therefore, within the integrated model, quality of life is proposed as the principal integral KPI of a smart city. This implies the formation of a combined evaluation system in which sectoral indicators (emissions, energy losses, travel time, recycling rates) are combined with socially oriented indicators (service accessibility, satisfaction, trust, digital inclusion, and environmental safety). Only under such a logic does strategic management acquire a truly human-centered meaning. A summary of global and Ukrainian experience across the key contours of the smart city is presented in Table 3.

This means that, in the author's model, quality of life is not a secondary effect of digitalization, but serves as the main criterion for selecting managerial decisions and assessing their long-term effectiveness.

Since achieving such effects requires a unified organizational environment, digital platforms play a key role in the modern city, serving as the organizational core of the smart city, because it is through them that data, services, users, analytics, and governance regulations are connected.

Table 3

Global and Ukrainian Experience Across the Key Dimensions of a Smart City

Component	Global experience	Ukrainian experience	Strategic conclusion
Smart governance	Singapore, Barcelona, and Vienna: a combination of data, participation, and interoperability	Diia, Kyiv Digital, open data, and digital consultations	The inclusion of digital services in strategies and budget KPIs is necessary
IoT and data	5G covers 55% of the world's population; digital twins are becoming a standard tool for planning	Transport validation systems, video analytics, smart metering, and local dispatch centers	Value emerges when unified data standards and scenario analysis are in place
Sustainable mobility	More than 17 million electric vehicles were sold worldwide in 2024; zero-emission zones are expanding	Ukraine's BEV market doubled in 2025; demand for charging infrastructure is emerging	Cities need integrated mobility platforms and the electrification of public transport
Energy	Global investment in power grids is expected to increase to USD 750 billion by 2030	3.29 million smart meters by the end of 2024; the digitalisation of metering is ongoing	The smart grid should be combined with building energy efficiency and the backup of critical infrastructure
Waste	Sensorization, routing, and the circular economy form the foundation of modern systems	Up to 13 million tonnes of municipal waste per year; a low recycling rate	Digital mapping of flows and planning of new waste infrastructure are needed
Platforms	The platform is becoming the core of urban governance and API ecosystems	High adoption of Diia and Kyiv Digital; Ukraine ranks 4th in Open Data Maturity	The next step is platform-based governance rather than just a set of services

Source: compiled by the author based on [4, 10, 11, 15].

Unlike a standalone information system, a platform performs an integrative function: it connects transactional services, communication with residents, dashboard tools, APIs for external services, open data, and feedback mechanisms. In this sense, the platform serves not merely as a digital interface, but as an institutional infrastructure of governance.

Global experience convincingly demonstrates the platformization of smart cities. Singapore is building a digital state through integrated public services, unified identification systems, and data-driven solutions; Barcelona uses a platform approach for open data and urban environment analytics; and European digital twin initiatives are developing standardized toolkits for cities of different sizes [1, 8]. A common feature of these models is the presence of a unified framework for data and service governance.

The Ukrainian experience is one of the most dynamic in Europe. Diia has become an example of the national platformization of services: in 2025, more than 23 million Ukrainians used the service [11]. At the municipal level, Kyiv Digital in 2024 demonstrated not only high penetration, but also multifunctionality – transport, surveys, notifications, local services, and interaction between residents and the city [10]. In addition, in 2025 Ukraine ranked 4th in the European Open Data Maturity ranking with a score of 97.1%, which indicates a high institutional capacity for opening and reusing data [14].

However, platform success is also associated with new challenges: cybersecurity, digital inequality, interoperability of local systems, data governance, and the risk of excessive centralization. Therefore, the strategic task of the city lies not only in launching an application or portal, but in establishing platform governance – the rules of data access, service prioritization, integration of external modules, and assessment of social impact.

The next step after forming the platform core is to incorporate digital services into the long-term logic of urban development. Thus, the integration of digital services into the strategic development of the city means that services are no longer viewed as isolated IT products of individual departments. They become elements of a unified urban development architecture, where each service is linked to strategic goals, budget programs, datasets, and target indicators of quality of life. Such an approach makes it possible to avoid duplication of solutions, increase the return on investment in digitalization, and ensure interaction across sectors.

In European and Asian cities, the model of a “service portfolio for urban strategy” is increasingly being applied, whereby transport, energy, environmental, security, and social services are treated as part of a portfolio of urban products. In this case, the question of whether a new digital service is worthwhile is no longer resolved according to the logic of “can we build it,” but rather according to the logic of “what strategic urban problem does it solve, what data does it use, what effect does it produce, and how can it be scaled?” It is precisely this logic that is a hallmark of mature smart governance.

For Ukraine, this approach is of particular value, since in reconstruction and recovery, resource constraints make the precise selection of digital priorities critically important. Cities do not need dozens of isolated applications, but rather a few interoperable platforms and modules working toward common goals: energy efficiency, mobility, transparency, environmental sustainability, security, and citizen participation. This requires the inclusion of the digital portfolio in community development strategies, informatization programs, resilience plans, and international technical assistance projects.

In this context, the principle of the “strategic alignment of services” is proposed: each digital service should be linked to a specific strategic goal, a set of indicators, a data source, a responsible unit, and a scaling scenario. It is precisely this type of integration that makes it possible to transform digital services into a real mechanism of urban development rather than a set of fragmented technological initiatives.

Thus, the platform and service contours should function as a unified system in which each digital product is connected with a specific governance problem, a data source, an expected effect, and a scaling scenario.

At the same time, the scaling of the approaches described above faces a number of institutional and resource barriers. Therefore, the main problem in implementing integrated models is the asymmetry between technological potential and institutional capacity. Many cities already have separate platforms, data, sensors, and digital services, but they do not have a unified data governance model, interdepartmental coordination, or a system of strategic KPIs. This generates duplication of functions, fragmentation of solutions, weak system interoperability, and the loss of economies of scale. A second problem is insufficient digital inclusion: not all residents have equal access to services, digital skills, and opportunities to influence urban decisions. A third challenge is cybersecurity and trust in data use.

For Ukraine, these challenges are compounded by the consequences of the war, damaged infrastructure, staffing limitations in communities, uneven local digital maturity, and the need to recover and modernize simultaneously. At the same time, it is precisely these circumstances that make integrated models especially necessary. Conditions of resource scarcity effectively compel cities to move toward more precise, data-driven governance, in which every investment must be assessed in terms of its multiplicative effect – economic, social, environmental, and security-related.

To deepen the practical verification of the model, it is advisable to apply a brief mini-pilot based on 5–7 indicators. For illustration, using the case of Kyiv, the following may be employed: the existence of approved KPIs for digital transformation; the number of integrated registers, APIs, and open datasets; the number of transport validations as an indicator of the platform’s transactional intensity; the share of consumers with smart meters; the coverage of the urban platform among users; the share of users who positively evaluate e-services; and the existence of digital participation tools and the speed of feedback. Such a mini-pilot does not exhaust all parameters of the model, but it demonstrates the possibility of moving from conceptual architecture to a measurable diagnosis of a community’s digital maturity. A preliminary interpretation of these indicators suggests that Kyiv already demonstrates signs of transition from a coordinated to an integrated level of maturity in the platform and data-interoperability contours, whereas the performance contour still requires a more systematic link between digital services and indicators of quality of life, trust, and resilience.

In view of this, the scientific novelty should be specified through a broader conceptual step. The article proposes not simply an integrated smart city model, but a polycentric adaptive-integrated architecture of strategic management that combines the external environment, the composition of actors, four functional contours, an adaptive governance cycle, and a system of multilevel outcomes. Its distinction from existing approaches lies in the simultaneous integration of social value, data interoperability, platform-based coordination, service implementation, and impact assessment.

The generalization of the above trends, cases, and statistical evidence makes it possible to argue that the proposed architecture places at its center not technology as such, but the alignment between goals, data, services, investments, and the impact on quality of life. In practical terms, the model can be applied as a diagnostic tool for a specific community: the strategic contour is assessed through the presence of approved KPIs and investment priorities; the data-interoperability contour through the number of integrated registers, APIs, sensor sources, and open datasets; the service contour through indicators of mobility, energy efficiency, waste management, and safety; the platform contour through user coverage, transaction intensity, participation, and speed of feedback; and the performance contour through the dynamics of quality of life, trust, and environmental and operational effects. For example, in the case of Kyiv, such a diagnosis can be based on data from the Kyiv Digital platform, transport validations, smart metering indicators, and open datasets, which makes it possible to assess not individual services, but the degree of their strategic integration. The logic of the step-by-step transition from fragmented digitalization to an adaptive value-oriented level is systematized in Table 4.

Table 4

Maturity Matrix of the Polycentric Adaptive-Integrated Model of Strategic Management for a Smart City

Level	Strategy	Data	Services	Platforms	Outcome
1. Fragmented	Separate projects	Disparate datasets	Standalone e-services	No integration	Localised effects
2. Coordinated	Digital priorities are in place	Basic data exchange	Sectoral dashboards	Portal/application	Improved access
3. Integrated	Shared city KPIs	APIs, standards, GIS	Transport, energy, and waste are interconnected	Unified city platform	Resource savings
4. Predictive	Scenario-based planning	Big Data, digital twin	Preventive management	Decision-making platform	Resilience and rapid response
5. Adaptive and value-driven	Policy shaped through quality-of-life KPIs	Continuous analytics	Personalised and inclusive services	Ecosystem of APIs and participation	Public value and trust

Source: author’s own development.

Based on the analysis conducted, the author’s polycentric adaptive-integrated model of strategic management for a smart city is proposed (Fig.), which may be applied both to highly developed metropolitan areas and to cities undergoing recovery. At its core lies not a particular digitalization tool, but social value, which is generated through the alignment of long-term goals, data, services, platforms, and investments. The model envisages a sequential transition through cycles of diagnosis, forecasting, coordination of actions, and evaluation of effects, while its substantive logic is consistent with the empirical generalizations presented in Table 3 and with the maturity matrix provided in Table 4.

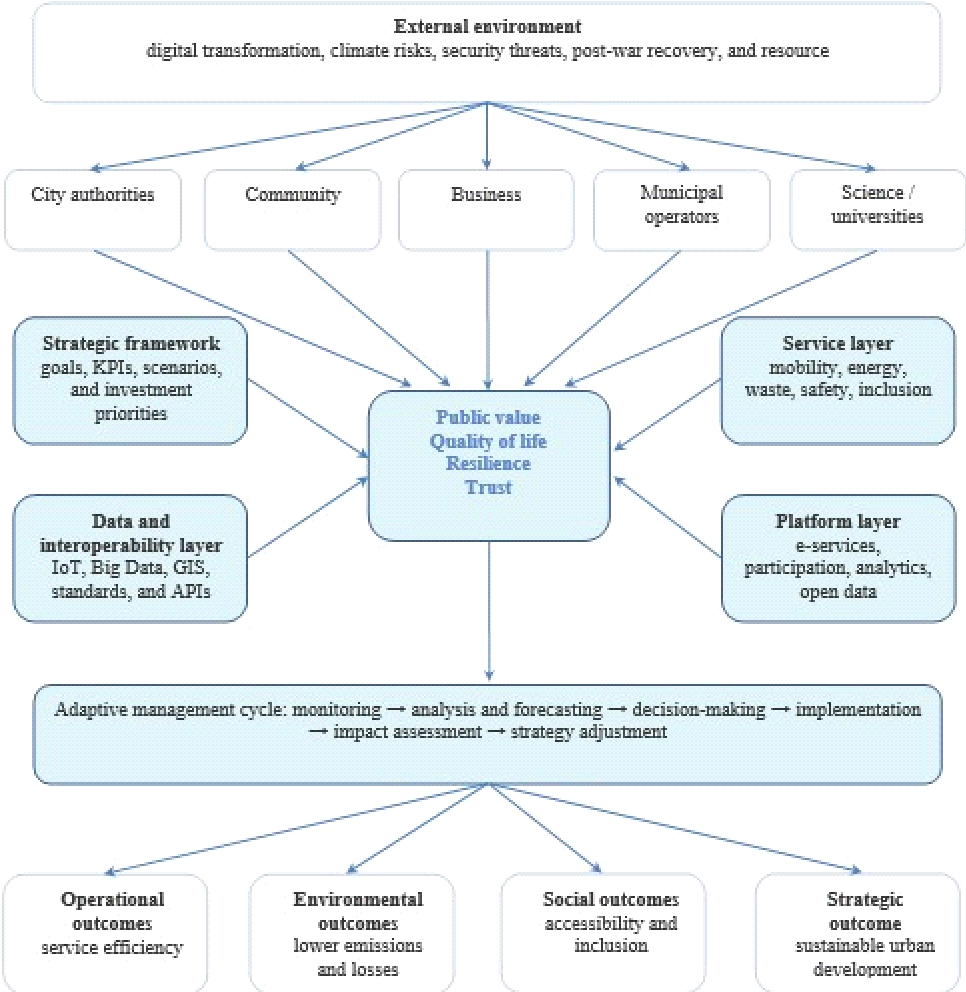

Fig. Polycentric Adaptive-Integrated Model of Strategic Management for a Smart City
Source: author’s own development

The first cycle – diagnostic – is based on the collection of data from IoT, registers, geoinformation systems, participation platforms, and service statistics. The second cycle – analytical and prognostic – involves the use of big data, digital twins, scenario analysis, and risk indicators. The third cycle – coordination and investment – transforms analytics into strategic priorities, budgetary decisions, and partnerships. The fourth cycle – social and performance-oriented – assesses changes in quality of life, service accessibility, environmental impact, resilience, and trust in institutions. It is precisely this cyclical structure that allows the model to remain adaptive rather than static; at the same time, Table 2 specifies the empirical content of its contours, while Table 3 outlines the logic of transition between maturity levels.

The proposed model has the potential for universal application to different types of cities and different stages of development – from modernization to post-crisis recovery. It may be used as a framework for smart city strategies, climate neutrality roadmaps, recovery programs, local digital twin projects, and systems for assessing the digital maturity of communities. For Ukraine, it is particularly important that the model makes it possible to integrate digitalization with security, the restoration of critical infrastructure, energy resilience, and openness of governance.

Conclusions

The article clarifies the meaning of the concept of the “smart city” and demonstrates that it should be viewed not as a set of separate digital solutions, but as a holistic system of strategic urban development management. The study summarizes current scholarly approaches to smart city and smart governance and systematizes global and Ukrainian experience in the fields of IoT, cloud services, big data, digital platforms, mobility, energy, and waste management. This made it possible to substantiate that the real effect of digital transformation arises not from the technologies themselves, but from their alignment with governance goals, data interoperability, stakeholder participation, and a system for evaluating results.

The main result of the article is the development of the author's polycentric adaptive-integrated model of strategic management for a smart city, which combines external challenges, the interaction of key actors in urban development, strategic, data-interoperability, service, and platform contours, as well as an orientation toward social value, quality of life, resilience, and trust. The practical significance of the obtained results lies in the fact that the proposed model may be used by local self-government bodies as a methodological foundation for preparing digital transformation strategies, recovery programs, policies for the development of urban platforms, energy efficiency, waste management, and the assessment of the digital maturity of communities.

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ВПРОВАДЖЕННЯ ІНТЕГРОВАНИХ МОДЕЛЕЙ СТРАТЕГІЧНОГО УПРАВЛІННЯ РОЗУМНИМИ МІСТАМИ

Чернова Н. С.

У статті розвинуто теоретико-методичні засади стратегічного управління розумними містами в умовах цифрової трансформації, кліматичних викликів, післявоєнного відновлення та зростання вимог до якості, доступності й стійкості міських послуг. Метою дослідження є обґрунтування поліцентричної адаптивно-інтегрованої моделі стратегічного управління розумним містом, яка поєднує стратегічне планування, інтероперабельність даних, цифрові платформи, сталі міські сервіси та оцінювання суспільного ефекту в межах єдиної управлінської архітектури. Методологічну основу дослідження становлять системний, інституційний, порівняльний, структурно-функціональний та кейс-орієнтований підходи. Це дало змогу узагальнити міжнародний і український досвід розумного врядування, використання Інтернету речей, хмарних сервісів, великих даних, цифрових платформ, екологічно чистої мобільності, розумних енергомереж і сучасних систем управління відходами. Наукова новизна дослідження полягає в розробленні авторської поліцентричної адаптивно-інтегрованої моделі, яка узгоджує цілі, акторів, дані, сервіси, інвестиції та показники якості життя і може застосовуватися для міст різного масштабу та різного рівня цифрової зрілості. Модель орієнтована не лише на впровадження технологій, а й на їх інтрацію у стратегічне прийняття рішень, міжсекторальну координацію, участь громадськості та вимірювану суспільну цінність. Практичне значення результатів полягає у можливості використання запропонованої моделі для підготовки муніципальних стратегій цифрової трансформації, планів відновлення, програм кліматичної нейтральності, дорожніх карт розвитку smart city, а також систем оцінювання цифрової зрілості та стійкості міських громад.

Ключові слова: розумне місто, стратегічне управління, розумне врядування, цифрові платформи, Інтернет речей, великі дані, енергоефективність, якість життя.

IMPLEMENTATION OF INTEGRATED MODELS OF STRATEGIC MANAGEMENT FOR SMART CITIES

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The article advances the theoretical and methodological foundations of strategic management for smart cities under conditions of digital transformation, climate challenges, post-war recovery and growing requirements for the quality, accessibility and resilience of urban services. The purpose of the study is to substantiate a polycentric adaptive-integrated model of strategic management for a smart city, which combines strategic planning, data interoperability, digital platforms, sustainable urban services and social impact assessment within a single governance architecture. The methodological framework is based on systemic, institutional, comparative, structural-functional and case-oriented approaches. This made it possible to generalize international and Ukrainian experience in smart governance, the use of the Internet of Things, cloud services, big data, digital platforms, environmentally friendly mobility, smart energy grids and modern waste management systems. The scientific novelty of the study lies in the development of the author’s polycentric adaptive-integrated model, which aligns goals, actors, data, services, investments and quality-of-life indicators and can be applied to cities of different sizes and levels of digital maturity. The model focuses not only on the introduction of technologies, but also on their integration into strategic decision-making, intersectoral coordination, public participation and measurable public value. The practical significance of the results lies in the possibility of using the proposed model for preparing municipal digital transformation strategies, recovery plans, climate neutrality programs, smart city development roadmaps, and systems for assessing the digital maturity and resilience of urban communities.

Keywords: smart city, strategic management, smart governance, digital platforms, Internet of Things, big data, energy efficiency, quality of life.

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