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AI-DRIVEN INNOVATION MANAGEMENT IN THE DEVELOPMENT OF SMART CITIES

Summary. The article considers artificial intelligence as a managerial tool for innovation development in smart cities. The relevance of the topic is determined by rapid urbanization, growing pressure on infrastructure, demand for sustainable services, and the need for data-driven governance. Attention is focused on the transformation of innovation management from reactive administration to proactive and predictive coordination. The paper discusses the smart city concept, the role of AI technologies in urban systems, international approaches to implementation, ethical and regulatory issues, and the challenges facing Ukrainian cities in the context of digital transformation and reconstruction. It also outlines the need to combine technological modernization with public trust, institutional capacity, and inclusive access to urban innovation.

Keywords: artificial intelligence; innovation management; investments; smart city; urban governance; business clusters; international cooperation; digitalization; digital transformation; sustainable development; post-war recovery.

Introduction and problem statement. In the context of rapid urbanization, growing competition among cities for talent and investment, and post-industrial transformation, innovation management has become a key element of modern urban governance. Traditional linear and hierarchical models are no longer able to respond effectively to the complexity and speed of change in contemporary cities. Artificial intelligence creates new opportunities for transforming innovation processes in smart cities.

AI improves urban governance and public services by supporting mobility, public safety, healthcare, education, utilities, environmental monitoring, and e-government. It enables better traffic regulation, resource management, waste control, and data-based decision-making. At the same time, its use involves risks related to personal data protection, ethics, algorithmic bias, cybersecurity, and regulatory inconsistency.

For Ukraine, AI-based innovation management is especially important in the context of digital transformation and post-war recovery, as reconstruction requires transparent, efficient, resilient, and human-centered decisions.

Analysis of recent research and publications. The theoretical basis of the study is formed by the works of leading scholars and experts in smart city development, innovation management, and digital governance. In particular, the works of W. Abdallah, M. Alghamdi, A. Caragliu, C. Christensen, H. Etzkowitz, R. Giffinger, P. Henman and R. Kitchin [1; 2; 3; 4; 5; 6; 7] outline the conceptual foundations of smart urban development, digital platforms, innovation ecosystems, business clusters and the socio-technical nature of urban governance. Ukrainian researchers, including H. Androshchuk, A. Zablovskyi, M. Zhyvko, N. Korotchenko, K. Kravets, O. Musii, A. Rachynskyi, and O. Sokhatska [8; 9; 10; 11; 12; 13; 14] have also

contributed to the analysis of digital transformation, innovation policy, and the management of urban development.

In academic discourse, the concept of the *smart city* is closely related to such notions as the *networked city*, *virtual city*, *intelligent city*, *digital city*, *knowledge city*, *sustainable city*, *green city*, *eco-city*, and *smart community*. These terms reflect different emphases in understanding urban development: digitalization, knowledge management, ecological sustainability, participatory governance, business clusters and the development of intellectual capital [9]. A. Caragliu, C. Del Bo, and P. Nijkamp [2] define a smart city as one in which investments in human and social capital, as well as traditional and modern ICT infrastructure, support sustainable economic growth and high quality of life through wise resource management and participatory governance.

A significant contribution to the conceptualization of smart cities was made by R. Giffinger and co-authors, who structured the smart city through six dimensions: smart economy, smart mobility, smart environment, smart people, smart living, and smart governance [5]. These dimensions are important for innovation management because each of them can act both as an object of technological transformation and as a source of new data, ideas, and management decisions. Analytical reports by UN-Habitat, the McKinsey Global Institute, the OECD, World Bank and the Ministry of Digital Transformation of Ukraine provide additional empirical and policy context for understanding the role of AI in urban development [15; 16; 17; 18].

Despite growing attention to smart cities and AI, several issues remain unresolved. Most studies emphasize technologies, while managerial mechanisms behind successful urban AI innovation are less examined. The role of AI across the full innovation cycle, from idea generation to evaluation and scaling, also needs clarification. In addition, public-sector innovation management must balance efficiency, participation, transparency, and protection against discrimination. For Ukraine, this problem is especially relevant, as international models must be adapted to wartime conditions, fragmented initiatives, staff shortages, external funding dependence, and the need for infrastructure reconstruction through technological, institutional, and social solutions.

Objectives of the article. The article aims to examine artificial intelligence as a tool for innovation management in smart city development and to identify the conditions for its effective implementation. The study clarifies the relationship between AI, smart cities, and innovation management; classifies relevant AI technologies; analyzes global and regional implementation models; summarizes economic and social effects; identifies key risks; and outlines recommendations for Ukrainian cities. The research applies theoretical analysis, generalization, synthesis, comparison, case study, statistical and graphical analysis. Based on systematized findings, practical recommendations are proposed for AI-based smart city development in the context of digital transformation and post-war reconstruction.

Results of the study. Modern cities face complex challenges caused by urban population growth and rising expectations for quality of life. This has strengthened interest in the smart city concept, which uses information and communication technologies to improve governance, sustainability, and urban comfort. Cities of different sizes implement smart city projects to increase management efficiency and support sustainable development.

Artificial intelligence plays a central role in smart city innovation management. Its development, from early algorithms to generative AI, shows a shift from routine automation to strategic decision support [19].

The main drivers of growth in the artificial intelligence market in smart cities include rapid urbanization, the need for effective management of traffic and energy consumption, the spread of IoT devices, growing attention to sustainable development, public safety concerns, and public-sector investment in digital infrastructure (fig. 1). The global smart city market reached USD 952 billion in 2025 and,

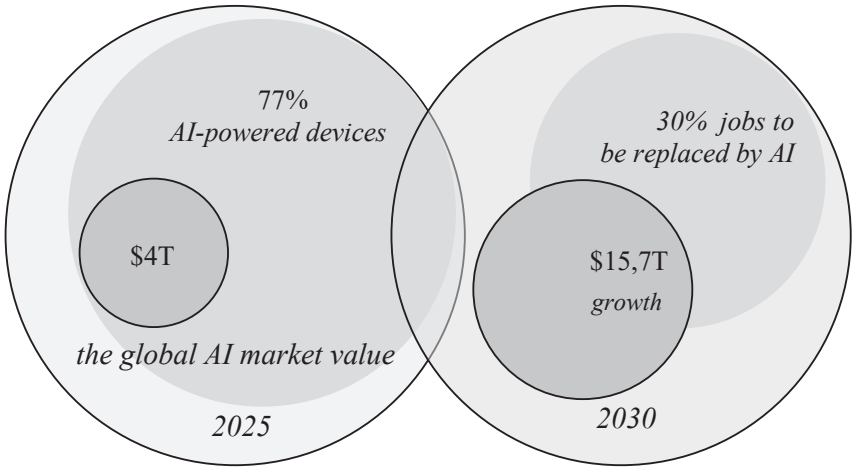

Figure 1. The AI market in 2025–2030

Source: [15]

according to forecasts, may exceed USD 6.3 trillion by 2034, growing at a compound annual growth rate of 23.2% [20].

Regional smart city implementation in 2025 shows three trends: North America leads in AI analytics and private-sector deployment, the Asia-Pacific region in infrastructure scale and state-led programs, and Europe in regulation and sustainable infrastructure investment. Understanding these differences helps cities and technology providers benchmark their practices globally (fig. 2) [20; 21].

The increasing role of AI and the Internet of Things is also visible in the dynamics of digital infrastructure. The compound annual growth rate of IoT in smart cities is expected to reach 22.5% by 2030; the number of active IoT devices in smart city environments exceeds 2.5 billion, and 58% of cities are already implementing active IoT integration programs [20]. These indicators show that AI and IoT are no longer auxiliary technologies, but core elements of city-scale infrastructure management.

Innovation management as a scientific and practical field covers the processes of planning, organizing, coordinating, and controlling innovation activity. Its theoretical foundation is the concept of an innovation system, in which innovation is understood as the result of interaction among different actors. In this context, the Quadruple Helix model is particularly important, as it provides for cooperation among universities, public authorities, business, and civil society (fig. 3). AI fits into this model as a cross-sectoral catalyst technology: it strengthens interaction among all four helices, accelerates knowledge transfer, and shortens the innovation cycle.

Artificial intelligence covers the entire innovation cycle: from the generation and selection of ideas to strategic planning and monitoring of results (tab. 1). The most tangible effects are the shortening of the innovation cycle by 20-25% and the increase in the number of implemented ideas by 35-40%. This makes AI not merely a technical instrument, but a multiplier of a city's innovation capacity. In management terms, the key transformation is the transition from fragmented projects to a coordinated platform logic of innovation development.

The smart city concept provides the key context for understanding AI in innovation management. Caragliu, Del Bo, and Nijkamp define a smart city through investments in human and social capital, ICT infrastructure, sustainable growth, quality of life, resource management, and participatory governance [2]. Thus, urban "smartness" depends not only on technology but also on the quality of management decisions [12]. Giffinger et al. identify six smart city dimensions: economy, mobility, environment, people, living, and governance [5]. AI integrates and optimizes

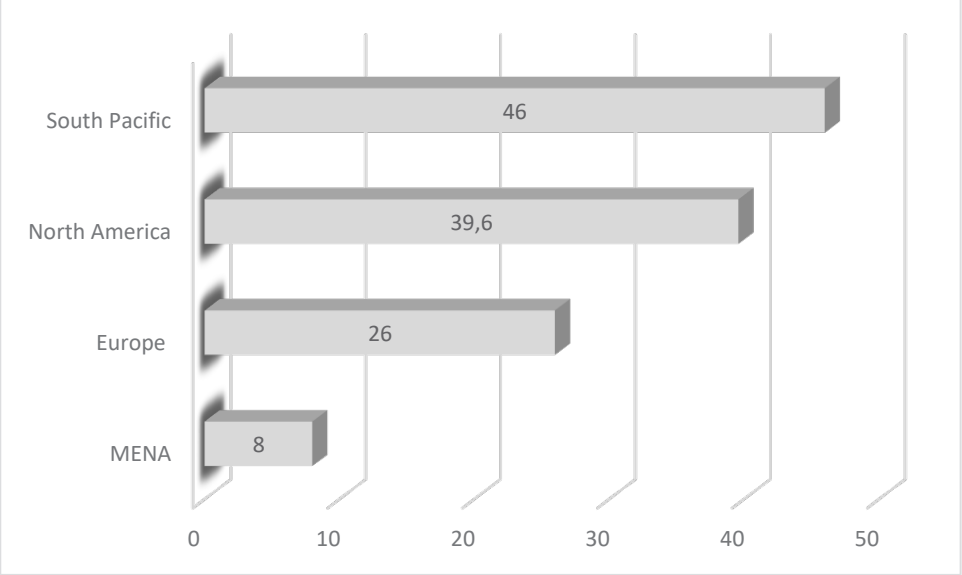

Figure 2. Distribution of the smart city market by continent, %, 2025

Source: [20]

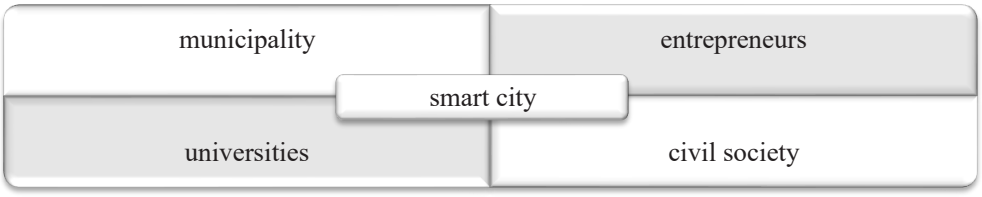

Figure 3. The Quadruple Helix model of innovation in a smart city

Source: [4; 20]

Table 1

Areas of artificial intelligence application in smart city innovation management

Area of innovation management	Examples of AI application	Expected effects
Idea generation and selection	NLP analysis of citizens' proposals; crowdsourcing on AI platforms; automatic ranking of ideas	Increase in the number of implemented initiatives by 35–40%
Management of R&D processes	Predictive analytics of project success; workflow automation; AI assistants for teams	Reduction of the development cycle by 20–25%
Technology transfer	Algorithms for university-business cooperation; technology mapping; patent AI analytics	Increase in the share of commercialized developments by 30%
Monitoring and evaluation	Real-time dashboards; AI audit of KPIs; automatic reporting	Transparency of spending and early identification of deviations
Strategic planning	Scenario modeling; ML-based foresight; analysis of global trends	Evidence-based decisions and strategic adaptability

Source: compiled by the authors [13; 20]

these dimensions, especially smart governance through e-democracy, open data, and algorithmic decision-making.

The classification of AI technologies demonstrates their specific role in different phases of the innovation process. Machine learning supports the analysis of existing innovations and forecasting of future needs; NLP collects and processes feedback from citizens and stakeholders; generative AI produces new solutions and prototypes on the basis of existing knowledge; and intelligent agents coordinate parts of the urban ecosystem in real time. ML and NLP demonstrate the greatest versatility, while generative AI has special importance for the ideation phase (tab. 2).

The global AI market in smart cities was valued at USD 50.63 billion in 2025 and is projected to reach USD 460.47 billion by 2034, with a CAGR of 27.80%. Its growth is driven by demand for sustainable, efficient urban solutions and the wider integration of AI into smart city services (fig. 4) [23].

Table 2

Classification of artificial intelligence technologies used in innovation management in smart cities

Type of AI technology	Area of application	Key functions	Role in the innovation process
Machine learning (ML)	Energy, transport, healthcare	Forecasting, optimization	Analysis of innovation data
Computer vision	Security, traffic control	Object detection, analysis	Monitoring of implementation
Natural language processing (NLP)	E-services, chatbots	Analysis of inquiries, automation	Collection of feedback
Generative AI	Design, R&D	Synthesis of ideas, prototyping	Generation of innovative solutions
Intelligent agents	Management, logistics	Autonomous response	Coordination of the ecosystem

Source: compiled by the authors [15]

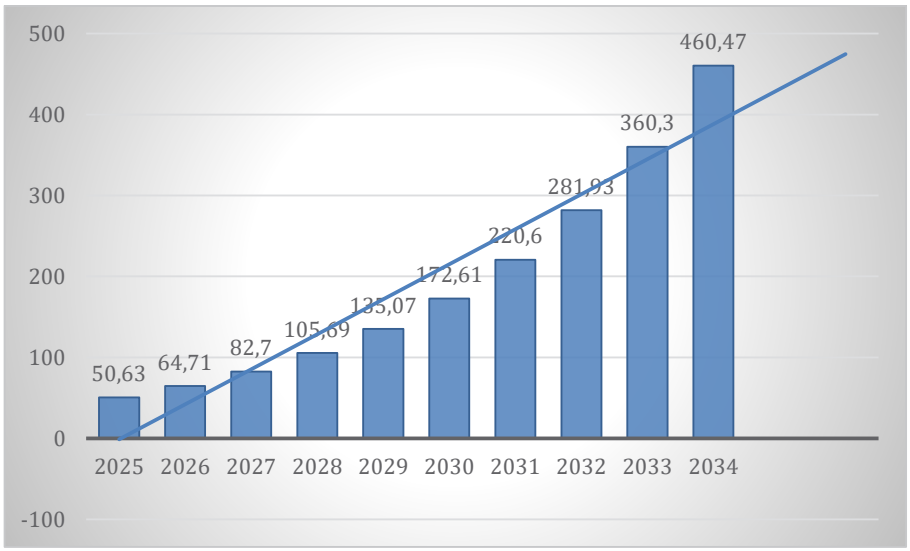

Figure 4. Size of the artificial intelligence market in smart cities

Source: [23]

An important theoretical framework is the concept of Platform Innovation Governance, in which AI functions not merely as a tool, but as a platform for coordinating different actors of the innovation ecosystem. In this paradigm, the city is considered an operating system, where data are a resource, AI algorithms are a processing mechanism, and public services and innovative products are the result. This model fundamentally changes the role of city authorities: from a traditional regulator to an operator of a digital development platform.

The analysis of global examples makes it possible to distinguish two key models: a technology-oriented model and a social-innovation model. Singapore and Tallinn represent the first model, in which AI is primarily a tool for system efficiency, administrative automation, and coordination of urban infrastructure. Barcelona and Helsinki represent the second model, in which AI strengthens citizen participation, transparency, and trust in innovation processes. Ukrainian cities can use a hybrid approach that combines the efficiency of the first model with the democratic orientation of the second.

International initiatives on AI regulation emphasize the need for algorithmic transparency, accountability, and respect for human rights. The Council of Europe, the EU AI Act, national strategies of several countries, and UN recommendations all underline that AI in public administration cannot be viewed only as a matter of efficiency. In urban innovation management, the legitimacy of algorithmic decisions depends on explainability, fairness, public trust, and mechanisms of civic control. Therefore, explainable AI is becoming an important principle of smart governance.

The dynamics presented in Table 4 indicate a transition from isolated pilot projects to systemic integration of AI into urban governance.

From 2025 to 2030, the global IoT market in smart cities is projected to grow from USD 269 billion to USD 742 billion, confirming the rapid expansion of IoT technologies and the growing role of digital infrastructure in urban management (fig. 5) [20].

Several AI-based innovation management models can be identified. Singapore applies a state-centered Smart Nation strategy, while Virtual Singapore uses IoT data to model urban development scenarios. Barcelona follows a decentralized approach through the Decidim platform, where NLP helps analyze and group citizen proposals. Germany emphasizes gradual AI integration with human oversight, which is especially relevant for Ukrainian cities. The United Kingdom uses GovTech platforms to prioritize public investment, while China's City Brain in Hangzhou represents a centralized model integrating cameras, traffic lights, and municipal services, though it raises privacy concerns. Tallinn's X-Road is particularly useful for Ukraine, showing that success depends on technology, legal frameworks, institutional vision, and public trust.

Smart city development in Ukraine combines strong technological potential and digital readiness with institutional limitations, resource shortages, and wartime challenges. Ukrainian cities differ significantly in digital maturity and AI implementation. Kyiv is the most technologically advanced and develops Kyiv Digital initiatives, but faces fragmentation and cybersecurity risks. Vinnytsia shows strong results among medium-sized cities, including heating cost savings through

Table 3

Main examples of AI application in innovation management in smart cities

City / Country	Innovation area	Role of AI	Result
Singapore	Smart Nation: IoT integration	Data management; predictive analytics	30% reduction in congestion; 15% reduction in energy consumption
Barcelona (Spain)	Decidim platform: bottom-up innovation	NLP clustering of citizens' ideas	40,000 participants; 70% of proposals implemented
Helsinki (Finland)	Forum Virium: open innovation	Explainable AI in decision-making	Increased trust and efficiency of e-services
Toronto (Canada)	Smart Waste: waste management	IoT + ML forecasting	18% reduction in logistics costs
Tallinn (Estonia)	X-Road: digital government	Algorithmic decision-making	90% of administrative decisions automated

Source: compiled by the authors on [15; 16; 21; 24; 25]

Table 4

Dynamics of the global AI market in smart cities

Indicator	2020	2022	2024	2030 (forecast)
AI market for smart cities, USD billion	12.4	21.8	38.6	105–130
Investment in innovative urban AI projects, USD billion	2.5	6.3	11.4	>=30
Share of AI in smart city spending, %	18	24	31	~45
Number of cities with an AI strategy, globally	~180	~320	~500	>1000
New jobs in the urban AI sector, thousand	–	340	610	>1500

Source: compiled by the authors on [15; 17]

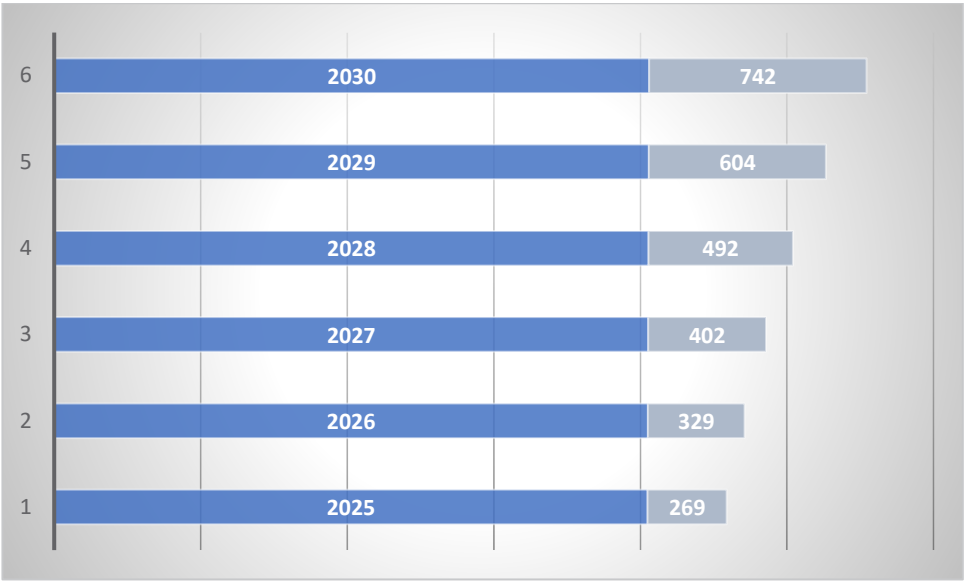

Figure 5. Global IoT market in the smart city sector, USD billion

Source: [20]

Table 5

State of digitalization and AI implementation in Ukrainian cities

City	Key AI initiatives	Maturity level	Main source of funding	Systemic gaps
Kyiv	Kyiv Digital; adaptive traffic management at >300 intersections	High	State budget, EU grants	Fragmentation, cybersecurity
Vinnytsia	GPS transport; smart building (-18% heating costs)	Medium	Local budget, USAID	Scaling of solutions
Dnipro	Dnipro-1 platform; AI chatbots (60% of inquiries)	Medium	Public-private partnership	System interoperability
Lviv	Smart Lviv; IT cluster; e-parking	Medium	EU grants, public-private partnership	Staff shortage in local government
Kharkiv	E-government, open data, security systems	Initial	State budget	Wartime restrictions, resources

Source: compiled by the authors on [18; 24; 26]

smart building systems, while Kharkiv remains at an initial stage because of wartime restrictions [24; 27].

Ukraine's digitalization framework includes the Digital Transformation Strategy until 2030, the Law on the National Informatization Program, regional programs, and the Diia platform. The Ministry of Digital Transformation supports AI development through Diia City, DREAM, and AI Ukraine. However, effectiveness depends on coordination between national and municipal levels.

Key limitations include fragmented pilot projects, staff shortages, weak regulation of algorithmic decisions, and dependence on external funding. At the same time, reconstruction creates an opportunity to introduce AI without outdated infrastructure.

AI-based innovations affect three key dimensions of the urban economy: the productivity of urban systems, resource allocation efficiency, and the quality of public services. They are used in mobility platforms, intelligent transport management, predictive maintenance, digital twins, and medical data systems. Modern smart city infrastructure increasingly depends on multi-level architecture that combines edge computing, 5G, IoT sensor networks, AI analytics,

Table 6

Assessment of the economic effect of implementing AI innovations in urban governance

Indicator	Minimum estimate	Maximum estimate
Overall economic impact of AI	USD 1.49 trillion	USD 2.95 trillion
Savings in municipal budgets due to AI innovations	12–15% of expenditures	25–30% of expenditures
GDP growth from investment in Smart City AI	USD 359.6 billion	USD 773.2 billion
Increase in labor productivity in AI sectors	+8%	+21%

Source: compiled by the authors on [8; 9; 28]

and integrated asset-management platforms. The economic effects of AI can be significant. Depending on the area of application, municipal cost savings may range from 12–15% to 25–30%, especially in lighting, energy efficiency, transport optimization, and waste management. However, such benefits require not only technological investment but also institutional capacity and transparent governance.

The impact on the urban labor market is mixed: some traditional functions are automated, while new professions emerge, including data analysts, AI auditors, smart system operators, and digital ethics specialists. Therefore, digital education and professional development for municipal employees are essential. At the same time, unequal access to AI-based services may deepen the digital divide, especially among older and vulnerable groups. Thus, digital inclusion and fair distribution of smart city benefits must become key principles of urban innovation policy.

Among the main problems of AI-based innovation management in cities are the lack of systemic integration, algorithmic bias, staff shortages, and legal uncertainty. Many cities introduce AI separately in transport, utilities, e-services, and safety, which prevents synergy and duplicates costs. Algorithms may also reproduce discrimination found in training data, while insufficient digital competences among public managers limit effective use. In addition, responsibility for algorithmic decisions remains unclear.

Modern urban concepts, such as sustainable, inclusive, resilient, safe, and creative cities, require different AI functions: video analytics, voice interfaces, equal-access systems, and predictive crisis management. Therefore, cities need a unified architectural framework that combines technical, institutional, and social solutions.

Effective AI implementation also depends on data governance. Smart cities collect data from transport, sensors, energy networks, public-service portals, and communication platforms. Without common standards, interoperability, and access rules, these data cannot support reliable decision-making. Municipal data platforms should therefore be treated as a basis for scaling AI innovations.

Another issue is the environmental footprint of AI, especially energy use, server infrastructure, and carbon emissions. City authorities should assess AI projects not only by economic efficiency but also by ecological impact. AI also changes public accountability, as responsibility may involve developers, data providers, managers, and policymakers. Urban AI strategies should include algorithmic audits, dataset documentation, public explanation of automated decisions, and appeal procedures.

Successful implementation requires more than technology procurement. It depends on institutional learning, partnerships, experimentation, and regulatory sandboxes for testing AI solutions before full-scale use.

For Ukrainian municipalities, a key task is to avoid excessive dependence on external vendors and fragmented grant-funded projects. International assistance is important for reconstruction and digital modernization, but sustainable innovation management requires local ownership of data, institutional memory, and internal competence. Cities need teams able to define technical requirements, assess AI products, negotiate with providers, and monitor implemented systems. Otherwise, smart city development may become a set of disconnected projects without strategic continuity.

The human-centered dimension of AI should remain a guiding principle. Smart city technologies should not replace democratic governance, but support more informed, transparent, and inclusive decisions. Citizen participation can be strengthened through proposal platforms, participatory budgeting, public dashboards, and NLP-based feedback tools. However, these instruments must include different age, social, and territorial groups, not only digitally active residents.

Cybersecurity is another critical condition. The more cities depend on integrated digital platforms, the more vulnerable they become to cyberattacks, data leaks, and manipulation of algorithmic systems. This is especially relevant for Ukraine under wartime and hybrid threats. Therefore, AI solutions must be implemented together with cybersecurity standards, backup systems, access-control policies, incident-response procedures, and continuous monitoring of critical infrastructure.

The scientific value of the proposed approach lies in understanding AI not as an isolated technology, but as part of a broader management system connecting data, institutions, infrastructure, regulation, competences, and civic participation. Its effectiveness should be assessed not only by technical indicators, but also by managerial outcomes: reduced duplication of costs, faster innovation cycles, better services, higher trust, resilience, and fairer access to urban opportunities.

Urban AI innovations also require measurable indicators, such as the share of AI-supported services, processing time for citizen requests, reuse of open datasets, audited algorithms, energy savings, citizen satisfaction, and accessibility for vulnerable groups. Without such indicators, AI implementation may remain declarative.

Special attention should be paid to integrating AI with post-war reconstruction platforms. Digital tools can support damage assessment, project prioritization, budget monitoring, and coordination among donors, state institutions, communities, and contractors. AI can increase transparency and reduce delays, but it must be combined with open data, public reporting, and clear responsibility for decisions.

The educational dimension is also important. Universities, municipal training centers, and professional associations should prepare specialists who combine urban management, data analytics, ethics, law, and public communication. The Quadruple Helix model can support local innovation laboratories and testing of solutions before their practical implementation.

Finally, AI-based innovation management requires transparent communication with society. Citizens should understand why algorithmic systems are introduced,

what data are used, how privacy is protected, and how they can influence decisions. At the strategic level, municipal AI policy should be linked with transport, energy, safety, environmental monitoring, healthcare, and administrative services through a common vision of sustainable and inclusive urban development.

Conclusions. The study shows that artificial intelligence is becoming a key tool of innovation management in smart city development. Its role goes beyond routine automation, as AI supports proactive, predictive, and platform-based urban governance. It helps generate and select ideas, forecast project success, automate administrative processes, monitor KPIs, support strategic planning, and coordinate cooperation among authorities, business, universities, and civil society.

AI-based innovation management includes three interrelated components: technological, managerial, and social. The technological component covers machine learning, computer vision, NLP, generative AI, and intelligent agents. The managerial component involves platform governance, coordination models, evidence-based decision-making, and innovation ecosystem development. The social component includes participation, trust, ethics, inclusiveness, and protection against discrimination.

International experience shows that there is no universal AI implementation model. Technology-oriented models ensure efficiency and coordination, while social-innovation models strengthen citizen participation. For Ukrainian cities, a hybrid approach is most appropriate, combining data-driven efficiency with transparency, public control, cybersecurity, regulatory clarity, and inclusive access to services.

Further research should focus on AI governance models for Ukrainian smart cities, algorithmic transparency, public-sector AI audit, assessment of social effects, integration of municipal platforms, digital competences of public servants, regulatory sandboxes, and adaptation of international best practices.

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УПРАВЛІННЯ ІННОВАЦІЙНИМ РОЗВИТКОМ РОЗУМНИХ МІСТ НА ОСНОВІ ШТУЧНОГО ІНТЕЛЕКТУ

Анотація. У статті розглянуто штучний інтелект як інструмент управління інноваціями у розвитку розумних міст. Актуальність теми зумовлена прискоренням урбанізації, зростанням навантаження на міську інфраструктуру, потребою у сталих публічних сервісах та переходом органів управління до рішень, що ґрунтуються на даних. Особливу увагу приділено зміні логіки інноваційного менеджменту: від реактивного адміністрування до проактивного, предиктивного й платформного управління міськими процесами. Окреслено теоретичні підходи до розумного міста, класифіковано ключові ШІ-технології, визначено їхню роль у генерації ідей, моніторингу, стратегічному плануванні, трансфері технологій та взаємодії учасників інноваційної екосистеми. Узагальнено міжнародний досвід застосування ШІ у міському середовищі, зокрема технологічно орієнтовані й соціально-інноваційні моделі. Висвітлено управлінські, етичні, правові та інституційні питання, пов'язані з алгоритмічною прозорістю, відповідальністю, цифровою нерівністю та кадровою спроможністю. Окремий акцент зроблено на українських містах, для яких упровадження ШІ пов'язане не лише з модернізацією управління, а й з повоєнним відновленням, посиленням стійкості, кібербезпеки та ефективності використання ресурсів. Показано, що ефективне використання ШІ у міському управлінні потребує узгодження технологічних, соціальних та інституційних рішень, формування культури відповідального використання алгоритмів, розвитку цифрових компетентностей управлінців і залучення громадян до оцінювання інноваційних змін. Такий підхід дає змогу розглядати розумне місто не лише як сукупність цифрових сервісів, а як відкриту інноваційну екосистему. Визначено коло питань, що потребують подальшого наукового осмислення, зокрема інтеграція розрізнених цифрових платформ, побудова механізмів аудиту алгоритмічних рішень, забезпечення рівного доступу до інтелектуальних сервісів і адаптація міжнародних практик до умов українських громад. Це особливо важливо для зміцнення стійкості міст, довіри населення та якості публічної політики.

Ключові слова: штучний інтелект; управління інноваціями; інвестиції; розумне місто; міське управління; бізнес-кластери; міжнародна кооперація; цифровізація; цифрова трансформація; сталий розвиток; післявоєнна відбудова.

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