



Methodical aspects of assessing the impact of implementation stages of smart city projects on the social and economic impacts¹

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Abstract. The study is devoted to solving the infrastructural problems of cities as one of the most serious challenges of modern urban development. Many cities are faced with aging infrastructure, which leads to frequent breakdowns, interruptions in the supply of water, electricity and other public services. These challenges complicate sustainable urban development and require an integrated approach that includes infrastructure modernization, implementation of innovative solutions, and

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active public participation in planning the urban environment. It has been established that certain aspects of the development of "smart" cities, such as the integration of sustainability into urban systems, the development of sustainable infrastructure and the use of technologies such as the Internet of Things and big data, should be thoroughly explored in the context of the recovery of Ukraine. It was determined that these areas are key to creating modern, smart cities that will be sustainable and environmentally sustainable. It is justified that by focusing on these aspects, Ukraine can develop an urban environment that effectively responds to both current needs and future challenges. The purpose of the article is to determine the effects of the implementation of smart city projects in connection with the stages of their implementation. It was determined that the implementation of the "smart city" concept is a continuous process that includes a number of elements that must be taken into account in the process of organization. It has been established that the ecosystem itself needs constant revision of conditions taking into account the current state and priorities, and this is one of the main requirements for successful implementation. It was determined that each city independently chooses and determines the directions of its smart development, depending on the priority tasks. For some cities, security issues are a priority, for others, improving the operation of public transport, and for others, reducing energy consumption in residential buildings. The analyzed smart city model is presented in the form of a basic leader city that implements innovative technologies and follower cities that adapt these technologies taking into account their specific needs and conditions. It has been established that such a model of a smart city, where there is a main leader city and follower cities, has a significant impact on the development of innovations, contributing to their acceleration, diffusion and improvement.

Keywords: smart city, projects, effects, stages, infrastructure, business, community.

Методичні аспекти оцінки впливу етапів реалізації проєктів розумних міст на соціально-економічні ефекти



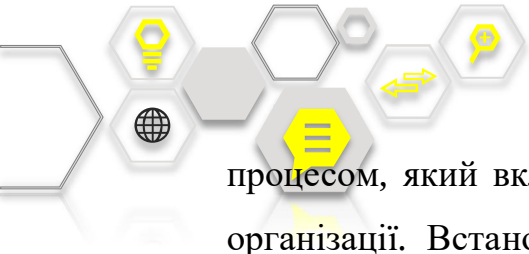
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Анотація. Дослідження присвячене вирішенню інфраструктурних проблем міст як одні з найсерйозніших викликів сучасного урбаністичного розвитку. Багато міст стикаються зі старіючою інфраструктурою, що призводить до частих збоїв, перерв у постачанні води, електроенергії та інших комунальних послуг. Ці проблеми ускладнюють сталий розвиток міст і потребують інтегрованого підходу, який включає модернізацію інфраструктури, впровадження інноваційних рішень та активну участь громадськості в плануванні міського середовища. Встановлено, що певні аспекти розвитку «розумних» міст, такі як інтеграція стійкості в міські системи, розвиток сталого інфраструктурного забезпечення та використання технологій, таких як Інтернет речей та великі дані, мають бути ретельно досліджені в контексті відновлення України. Визначено, що ці напрями є ключовими для створення сучасних, розумних міст, які будуть стійкими та екологічно сталими. Обґрунтовано, що зосереджуючись на цих аспектах, Україна може розвивати міське середовище, яке ефективно відповідає як на сучасні потреби, так і на майбутні виклики. Метою статті є визначення ефектів від впровадження проєктів розумних міст у зв'язку з етапами їх реалізації. Визначено, що впровадження концепції «розумного міста» є безперервним



процесом, який включає ряд елементів, що мають бути враховані в процесі організації. Встановлено, що екосистема смарт міста потребує постійного перегляду умов з урахуванням поточного стану та пріоритетів, і це є однією з основних вимог для успішного впровадження. Визначено, що кожне місто самостійно обирає та визначає напрямки свого розумного розвитку, залежно від пріоритетних завдань. Для одних міст пріоритетними є проблеми, пов'язані з безпекою, для інших – покращення роботи громадського транспорту, а для третіх – зниження енергоспоживання у житлових будинках. Проаналізована модель розумного міста представлена у вигляді базового міста-лідера, яке впроваджує інноваційні технології, та міст-послідовників, що адаптують ці технології з урахуванням своїх специфічних потреб і умов. Встановлено, що така модель розумного міста, де є основне місто-лідер та міста-послідовники, має значний вплив на розвиток інновацій, сприяючи їх прискоренню, дифузії та вдосконаленню.

Ключові слова: смарт сіті, проєкти, ефекти, етапи, інфраструктура, бізнес, громада.

Statement of the problem. Infrastructural problems of cities are one of the most serious challenges of modern urban development. Many cities face aging infrastructure, which leads to frequent breakdowns, interruptions in the supply of water, electricity and other public services. In addition, the insufficient capacity of transport systems leads to traffic jams, air pollution and wasted time, which negatively affects the economy and the quality of life of residents. There is also a shortage of affordable housing in many cities, leading to growing social inequality and the emergence of slums. These problems complicate the sustainable development of cities and require an integrated approach, which includes modernization of infrastructure, implementation of innovative solutions and active participation of the public in the planning of the urban environment.

Literature Review. Gracias et al. [1] and Anthopoulos [2] offer comprehensive literature reviews on the smart city domain. Gracias et al. present a structured review



highlighting key trends and developments in the field, while Anthopoulos explores the foundational concepts and challenges associated with smart city implementations. These reviews are essential for understanding the current state and theoretical underpinnings of smart city research.

Several sources delve into specific case studies and comparative analyses of smart city initiatives. Zhang et al. [3] discuss lessons learned from China's preparation for the 13th Five-Year Plan for smart cities, highlighting the complexities of planning large-scale smart city projects. Similarly, Hu and Zheng [6] provide a comparative study of smart city initiatives in American and Chinese cities, offering insights into the different approaches and outcomes in these two regions.

Tzioutziou and Xenidis [4] examine the integration of resilience and smart city concepts in urban systems, emphasizing the importance of combining these frameworks to enhance urban sustainability and security. Wiig [5] critiques IBM's techno-utopian vision for smart cities, exploring the policy implications and mobility challenges associated with such an approach.

Bibri and Krogstie [7] provide an extensive interdisciplinary literature review on smart sustainable cities, outlining the future prospects and challenges in this area. Their work is crucial for understanding the long-term sustainability implications of smart city initiatives.

Li et al. [8] discuss the role of big data and deep learning in the digital twins of smart cities, focusing on the Internet of Things (IoT) as a critical component of smart city infrastructure. Omelyanenko et al. [13-15] also contribute to the discussion by exploring infrastructure and service methodologies for smart cities, with a particular focus on post-war recovery and the development of innovative communities.

Industry reports such as the McKinsey Global Institute [9] and MINDGRUB [10] provide practical insights into how smart cities can leverage digital solutions to improve livability and how businesses can contribute to smart city success. These reports are valuable resources for practitioners and policymakers involved in smart city development.



Ukrainian sources [11; 12] offer a localized perspective on smart city concepts, exploring how these technologies are being implemented in Ukrainian cities. These articles are particularly relevant for understanding the regional adaptation of smart city frameworks in different geopolitical contexts.

By reviewing these sources, one can gain a comprehensive understanding of the diverse approaches, challenges, and future directions in the field of smart cities.

Prospective studies. Aspects of the general problem that remain unresolved and require additional research in the conditions of Ukraine, in particular in the context of the post-war reconstruction of the infrastructure on a “build back better” basis, include the question of the phasing of the implementation (deployment) of smart city projects, taking into account the ratio of outputs - results.

The purpose of the article is to determine the effects of the implementation of smart city projects in relation to the stages of their implementation.

Main material. Currently, half of the world's population lives in cities - by 2030, this number may increase to 5 billion. To cope with such growth, the government must find ways to protect the safety of citizens and improve the quality of life while using the budget more efficiently. In other words, they have to work smarter. The UN predicts that in 30 years, 67% of the world's population will live in cities, while today this indicator is about 57.5%. At the same time, it should be taken into account that 8.08 billion people live on Earth today, and in 2050 this figure will reach 9.7 billion. It turns out that there are currently about 4.65 billion citizens on our planet, and in the next 30 years there will be 6.5 billion [1].

Already today, the problem of overpopulation manifests itself in many megacities of our planet. Space and resources are often used inefficiently, garbage is not cleaned in time, and people stand in queues. All such problems should be solved by Smart City projects.

Smart City projects have become a key direction in the development of modern urban centers. Their goal is to use information and communication technologies (ICT) to improve the quality of life of residents, improve the efficiency of urban resource management, reduce negative environmental impact and stimulate



economic growth.



Smart City is an interdependent system of communication and information technologies with the Internet of Things (IoT), which simplifies the management of internal processes and improves the standard of living of the population. Smart City performs two important tasks: collecting and transferring data to management representatives and, accordingly, establishing feedback between the administration and citizens.

Citizens are aware that a successful Smart City construction strategy requires the creation of a functioning ecosystem that will allow coordination of key players (region, affiliated organizations, public and private sectors, population, etc.) and effectively coordinate Smart City construction initiatives to implement the strategy and goals accordingly to his priorities.

Implementation of the Smart City concept is a continuous process. Its ecosystem contains a number of elements that must be taken into account in the process of organization. The ecosystem itself requires a constant review of conditions taking into account the current state and priorities and is one of the main requirements for successful implementation.

Each city chooses and determines the directions of smart development independently. Each city, as a rule, has its own priority tasks. For some, these are security-related problems, for others, improving the operation of public transport, for others, reducing energy consumption in homes. But no problem will be effectively solved until the city has a basic smart infrastructure that resembles an advanced city telecom operator.

The main obstacle to its development is the lack of budget funds. The functionality of a smart city mostly requires serious investments without the possibility of direct returns over time. It is clear that video recording cameras are able to some extent not only to reflect the costs of them, but also to bring in profits as long as there are negligent drivers. But it will not be forever, and even more so, applications that show cameras on the roads will immediately appear.

Therefore, it is important to move as soon as possible to the third phase of

building a smart city, the main idea of which is to create infrastructure not only for the city, but also for its use by businesses, startups and other consumers.

The effects of the implementation of Smart City projects are multifaceted and relate to various aspects of community.

One of the main economic effects is the increase in the efficiency of resource use. Smart City projects, as a rule, are aimed at optimizing the use of energy, water and other important resources. For example, with the help of intelligent energy consumption monitoring systems, it is possible to automatically regulate electricity consumption in buildings, which allows reducing energy costs and increasing energy efficiency. Such systems not only help save money for residents, but also reduce the burden on the city's infrastructure, which in the long run leads to lower costs for its maintenance and renewal.

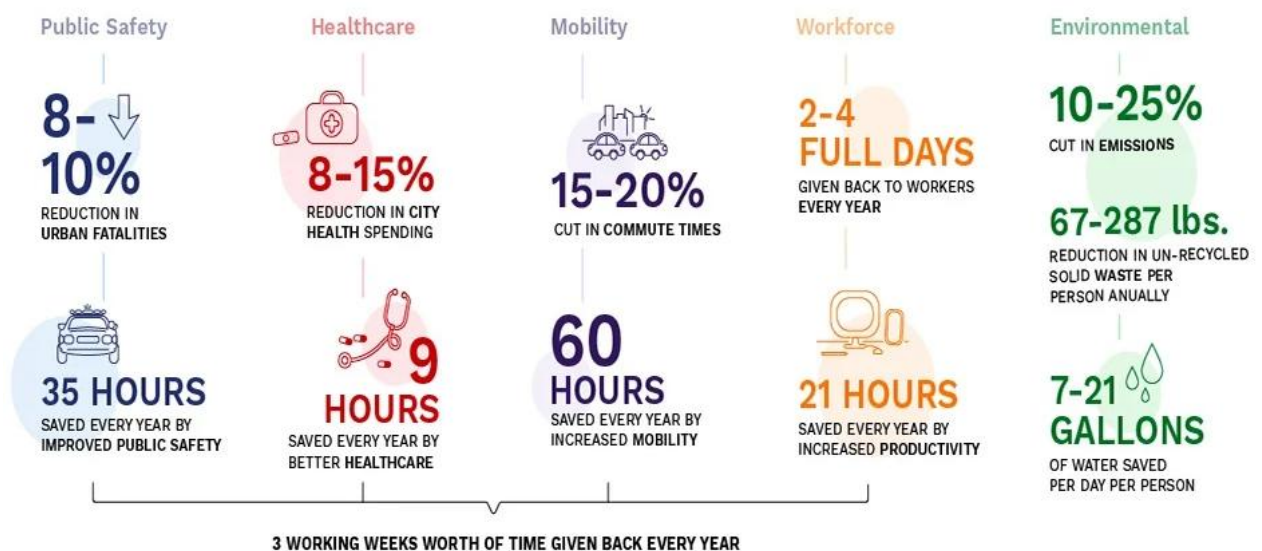


Fig. 1. Impact of smart technologies on cities [10]

Another important aspect is increasing the attractiveness of the city for business and investors. Smart cities create a favorable environment for the development of innovative businesses, attracting startups and technology companies that use the latest ICT opportunities to create new products and services. A high level of technological development, the integration of digital solutions in various areas of urban life, as well as the presence of intelligent infrastructure make cities more



attractive to investors who are ready to invest in the development of such technologies. This stimulates the creation of new jobs, increasing the level of employment and increasing revenues to local budgets.

In addition, Smart City projects contribute to the development of new sectors of the economy. In particular, the introduction of intelligent transport systems, traffic management systems and other innovative solutions stimulates the development of related industries, such as software production, development of sensor technologies and automation tools. The demand for highly qualified specialists in the field of ICT is growing, which, in turn, contributes to the development of educational programs and an increase in the level of professional training.

An important aspect is the improvement of the quality of life of residents, which has indirect economic effects. Increasing the level of comfort, safety and environmental awareness of residents contributes to increasing their productivity and well-being. For example, the use of intelligent security systems that monitor public spaces and respond to potential threats increases the level of public security. This, in turn, helps to increase consumer activity and reduce the level of social conflicts.

The economic effects of Smart City projects are also manifested in the stimulation of environmental sustainability of urban environments. The implementation of intelligent systems of waste management, air and water quality monitoring, as well as other environmental solutions helps to reduce the negative impact on the environment and reduce the costs of eliminating the consequences of environmental disasters. This helps increase the environmental responsibility of businesses and city residents, which, in turn, can lead to the emergence of new environmental initiatives and projects.

Smart city technologies have immense yet largely untapped potential to enhance the quality of life. The core concept of smart cities is to purposefully utilize technology and data to make informed decisions and improve living conditions. In addition to benefits related to safety, time, health, connectivity, employment, and cost of living, significant advancements can be achieved in the environmental sector.



Smart city solutions, such as air quality monitoring, energy consumption optimization, and tracking of electricity, water, and waste, can lead to a reduction of greenhouse gas emissions by 10-15%, a decrease of 30-130 kilograms of solid waste per person annually, and water savings of 25-80 liters per person per day [9].

Smart solutions have the capability to enhance various aspects of urban life. To realize such benefits, a city needs to build on three layers of "smartness," complementing traditional physical and social infrastructure. The first layer is the technology base, which includes networks of connected devices and sensors, such as smartphones linked by high-speed communication networks. The second layer involves smart applications and data analysis capabilities that translate raw data into alerts, insights, and actions. Finally, the third layer encompasses the widespread adoption of applications and their use by cities, businesses, and the public, coupled with effective data management, which drives better decision-making and behavior change.

Smart applications that contribute most significantly to environmental improvements include (but are not limited to) those focused on mobility, water, energy, and waste. For instance, real-time public transit information and building automation systems can reduce greenhouse gas emissions; improved air quality can be a secondary benefit of many energy-saving and mobility applications; leak detection and control can aid in water conservation; and digital tracking and payment for waste disposal can lead to a reduction in solid waste.

In a recent study on smart cities, the McKinsey Global Institute examines how technology can improve the quality of life, including an analysis of smart applications that will be relevant for cities through 2025. The findings suggest that smart technologies could enhance key indicators by 10–30% once implemented, and that utilizing the current generation of smart city applications could significantly or moderately help cities make progress toward achieving 70% of the Sustainable Development Goals [9].

The implementation of Smart City is a step-by-step process, each step of which contributes to the achievement of various economic effects that accumulate over



time and form a complex impact on the city economy. Let's consider in more detail how these stages are related to economic effects.

The first stage of Smart City implementation begins with detailed planning, analysis of the city's needs and development of a strategy. At this stage, investments are attracted, both from public and private investors. Economic effects are manifested here in the form of intensification of investment activity, which stimulates the local economy. The creation of project plans and technical and economic justifications requires the involvement of specialists from various fields - engineers, architects, IT specialists, analysts, which contributes to the increase of employment and the development of new professional areas.

In addition, at this stage, the development and implementation of the legal framework necessary for the implementation of Smart City projects is taking place. This can attract experts in the field of law, economics and management, which also contributes to the creation of new jobs and increasing the level of professional training.

The next stage includes the development and implementation of technologies necessary for the operation of a smart city. This may include the implementation of intelligent transport systems, resource monitoring and management systems, digital platforms for citizens to interact with the authorities, etc. At this stage, economic effects begin to manifest themselves through increased efficiency in the use of urban resources, reduced costs of energy, water, transport, and other important aspects of urban infrastructure.

For example, intelligent traffic management systems reduce congestion, which, in turn, reduces fuel costs, shortens travel time and reduces the level of emissions of harmful substances into the atmosphere. This contributes both to cost savings and to the improvement of the ecological situation in the city, which also has an economic impact, in particular in the form of a reduction in health care costs.

Also, at this stage, the sphere of research and development (R&D) is activated. The creation and introduction of new technologies stimulates innovation, which can become the basis for the development of new businesses. This creates conditions for



the formation of new industries, an increase in the number of startups and high-tech enterprises, which, in turn, leads to an increase in employment and an increase in the income of the population.

At the stage of integration and scaling, implemented solutions extend to various spheres of city life, ensuring their interaction and a comprehensive approach to city management. This includes the integration of various systems – from energy management to the provision of medical services and security.

The economic effects of this stage include further cost reductions due to the synergistic effect of systems integration. For example, the integration of the energy consumption management system with the monitoring and management systems of buildings allows to achieve greater energy efficiency, which reduces the overall costs of operating the city infrastructure.

In addition, the scaling of technologies to the entire urban space increases the level of comfort and quality of life of residents, which in the long term stimulates economic growth. Productivity increases as residents spend less time commuting, receive better services, and live in a safer, greener environment. It also increases the attractiveness of the city for new investors looking for a favorable environment for business development.

After integration and scaling, Smart City enters the operational phase, where the main focus is on maintaining and optimizing existing systems. At this stage, the economic effects are focused on optimizing costs and improving the efficiency of urban resource management. This is achieved through the use of big data (Big Data) and analytics to make informed decisions about urban infrastructure management.

For example, analytical systems can predict energy and water consumption, optimizing supplies according to actual needs. This makes it possible to reduce the costs of production and supply of resources, as well as to avoid excessive load on the infrastructure. In addition, smart systems can quickly respond to emergency situations, which reduces the risk of additional costs.

Another important economic effect is the creation of new sources of income for the city. Intelligent cities can offer paid services, such as the use of intelligent



parking or notification systems, which allows to increase the income of local budgets. It also helps reduce dependence on state funding and increases the city's financial stability.

In the final phase, when the Smart City is operating at full capacity, long-term economic effects are felt. This includes sustainable economic development, which is ensured by increasing the competitiveness of the city at the global level. Smart cities are becoming hubs of innovation, attracting international investment and talent, fueling the development of new economic sectors such as green energy, IT, and creative industries.

Improving the quality of life for residents also has long-term economic effects. Happy and healthy residents are more productive and more involved in the social and economic life of the city. This leads to an increase in consumer activity, the creation of new jobs in the service sector and an increase in tax revenues for the city budget.

In general, each stage of implementation of the Smart City project has its own specific economic effects, which together contribute to the comprehensive economic development of the city. From initial investment attraction to long-term competitiveness enhancement, these effects create the basis for sustainable economic growth and improved quality of life for residents.

The smart city model can be presented as a basic leader city that implements innovative technologies, and follower cities that adapt these technologies taking into account their specific needs and conditions.

It is a city that primarily implements the latest technologies, develops standards and strategies for a smart city. It acts as a testing ground for new solutions such as smart infrastructure, monitoring technologies, data analysis and the integration of digital services in various aspects of urban life. The main city actively cooperates with scientific institutions, technological companies and government structures to create comprehensive and effective solutions.

These are cities that adopt successful practices and technologies tested in the leading city and adapt them to their local conditions. They can use ready-made



solutions that have proven their effectiveness, but with modifications that take into account the characteristics of the population, geographical location, economy and existing infrastructure. Follower cities can also cooperate with the leader city in the framework of joint projects or experience exchange programs, which helps to accelerate the implementation of smart solutions.

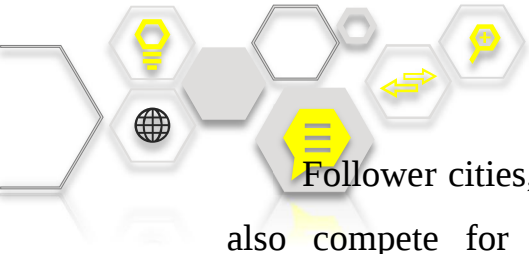
The smart city model, where there is a main leader city and follower cities, has a significant impact on the development of innovations, contributing to their acceleration, diffusion and improvement.

The main leading city, as a pioneer in the implementation of smart technologies, creates conditions for rapid testing and improvement of new solutions. This city takes the risk of experimentation and early implementation, which allows to reduce the time from idea to real application. Follower cities can pick up already tested innovations, reducing the time for their own research and development, and thus speeding up the innovation cycle.

Thanks to the cooperation between the leader city and the follower cities, innovative solutions quickly spread throughout the network. This ensures large-scale implementation of the latest technologies and practices in different regions and conditions. Follower cities gain access to cutting-edge solutions and can adapt them to their needs, allowing them to remain competitive and effective in solving urban challenges.

Since the leader city bears the main costs of developing and testing new technologies, follower cities can reduce their own costs of innovation. They get access to technologies that have already passed the stage of testing and refinement, which reduces the risks and costs of their integration. This stimulates more cities to adopt innovative solutions, promoting their diffusion.

The model with a leader city and followers also helps to improve the quality of innovation. As different cities apply smart solutions in different environments, they discover the strengths and weaknesses of these solutions. This allows us to improve technologies based on feedback from multiple sources and make them more versatile and adaptable to different conditions.



Follower cities, having access to innovation, can not only copy solutions, but also compete for the introduction of even more efficient and progressive technologies. This creates healthy competition between cities, which stimulates further development of innovation. At the same time, cooperation between cities in the network allows to exchange experience and jointly solve problems that arise in the process of introducing new technologies.

At the global level, this model contributes to the creation of a network of innovative cities that not only implement advanced technologies, but also become platforms for further research and development. This contributes to the global spread of innovations, which leads to sustainable development, reducing the environmental burden and improving the quality of life in different parts of the world.

Thus, a smart city model with a core city and follower cities not only accelerates the development of innovations, but also ensures their effective implementation and adaptation, contributing to sustainable development and improving the quality of life in cities around the world.

Conclusions. Thus, the effects of Smart City projects are multifaceted and have a positive impact on various aspects of city life. They contribute to increasing the efficiency of the use of resources, stimulate the development of new sectors of the economy, improve the quality of life of residents and contribute to the ecological sustainability of urban environments.

Given the global trends of urbanization and the development of digital technologies, the implementation of Smart City projects will be an important factor in ensuring sustainable economic growth and increasing the competitiveness of cities in the future.

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