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**Review Paper**

# Theory and Practice of Public Management of Smart Infrastructure in the Conditions of the Digital Society' Development: Socio-economic Aspects

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**ABSTRACT**

Today, cities represent the leading form of territorial and socio-economic organization of modern society. The formation of a smart city based on smart infrastructure as its core essence is a trend that covers a number of cities on all continents of the planet. Based on the analysis of research in the field of smart infrastructure and its components, and the management of this infrastructure in smart cities, as well as trends in the creation and development of smart cities in terms of socio-economic implications, the conclusion is made about the need for "smart governance" to pay attention to the processes of socio-spatial development and taking into account the needs of citizens, in order to avoid the occurrence of bilateral negative effects digital inequality on the one hand and an unjustified increase in public spending on the other hand.

**HIGHLIGHTS**

- The article is devoted to the analysis of smart infrastructure and smart city concepts and their practical implementation, including arising challenges, from the angle of view of public management
- The obtained results demonstrated the necessity of systemic approach in public management of planning, development, an functioning of smart cities, based on identifying and removing barriers that create a gap between stated city goals and actual practice, with an eye to the motives and needs of human and creative capital
- The practical significance of the research lies in outlining of key implications and challenges in today public management of smart infrastructure in the conditions of the digital society' development, within the frames of smart cities planning and functioning

**Keywords:** Public Management, Smart City, Smart Infrastructure, Technology, Human Capital

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Today, cities face the challenge of technological development, infrastructural changes, need for rational use of resources and the involvement of modern technologies in administrative management. In the case of a competent policy, cities can transform into so-called smart cities the practical embodiment of intellectual capital in the form of projects and initiatives for urban development, carried out in order to maximize the use of resources, attract human capital and technology. Such cities are 'engines' for developing countries. However, their technological essence makes a citizen a user of goods and services, while the very concept of a smart city creates the conditions for automatic management of the city and impersonal citizens. Aspects of public administration and the role of the citizen in the concept of smart cities lead to the need to transform public policy institutions.

Residents of the city produce and consume huge amounts of information, they form communities in the virtual space and are more willing to build interactions and make purchases via the Internet (Guseva *et al.* 2022). Recently, models for constructing analysis through conceptualization and patterning have become popular. A well-known project management methodology was proposed by Peter Drucker, who used the term SMART as early as 1954. This term is an abbreviation of five goals: specific; measurable; achievable; realistic (and pragmatic); timed (defined in time). Subsequently, the term "smart city" appears, which also embodies the conceptual units of analysis, while the emphasis is made on socio-economic development through the introduction of technologies that allow collecting and analyzing information about the city and its inhabitants. The managerial tasks are to clarify the "rules of the game" in the information space and manage development through open source management, which implies greater involvement of citizens in public politics (Ladonko *et al.* 2022).

The transformation of public administration requires the existence of so-called "smart communities" managed on the principles of collective intelligence (Ahvenniemi *et al.* 2017; Rozskazov *et al.* 2021). The role of technology in such management can be defined as a system of interactions, an analogy for which is the Visa system (the creation of uniform rules for use, the existence of autonomous regulatory structures and openness of access for each participant as a cardholder).

Smart city architecture integrates geographic data about a city: space, place, landscape, and scale. Thus, the concept described by Beatley back in 2012 reflects a set of learning rules that make it possible to create a design of cities close to nature, the design of houses in which integrates natural features and properties. Such "biophilic" cities include Singapore, Oslo, San Francisco, etc. (Albino, Berardi and Dangelico, 2015; Kim, Sabri, and Kent, 2020). The social context of the space is reflected in the "humanistic geography", the civic sense of the territory.

Infrastructure is a large-scale element in assessing the development of the city, it includes material components: buildings, streets, transport. The current transformation of the economy is associated with the transition to alternative energy sources and a decrease in energy intensity due to the optimization of the use of energy resources. The global interest in renewable energy is attracting huge investments in such projects. Urban infrastructure has great potential for the application of new technologies (Khan *et al.* 2021). For example, in the Netherlands, electricity is generated by placing solar panels on asphalt. Such roads were built as part of the Solaroad pilot project. The total application of modern technologies is demonstrated in Japan, where the innovative and green city of Fujisawa is built, in which more than 30% of electricity is generated from solar energy and green transport is widespread (Yigitcanlar *et al.* 2018).

The need to develop a new "political economy of sustainable development" moves this issue from the fringes of the global economic debate to its center. Today, two leading areas of modernization or creation of a qualitatively new urban environment can be distinguished: the concept of sustainable development and the concept of a smart city. The concept of a smart city as a whole complements the idea of sustainable development, taking into account infrastructural, institutional factors, and the factor of human influence on all processes of urban development.

The combination of digital technologies and physical infrastructure of the city gave rise to the development of smart infrastructure. Its advantages are significant, but depend on society's ability to adapt to it in a short time. Smart-infrastructure aims at effective use of the resources of the urban

environment by all its participants in order to ensure a more comfortable, safe, and ecologically clean life. Smart infrastructure does not just solve the issue of creating less polluted or more efficient areas, but generates significant political capital and great business opportunities (Kuzmina *et al.* 2021; Zoska *et al.* 2020). The main argument in favor of smart-infrastructure facilities is compliance with the needs of society while implementing the concept of sustainable development. With the effective use of smart infrastructure, city dwellers will have a comfortable and safe living environment. First of all, this concerns the processes of digitization of the utilities, energy, construction and public transport sectors, the large-scale use of integrated digital platforms in the management of the city, in the educational process, in the medical sector, as well as for the control of environmental protection (Klymenko *et al.* 2016). At the same time, smart infrastructure is not a "panacea" for all the city's problems, and in some cases it can generate a number of additional challenges: violation of the privacy of private life, risk of technical malfunction, reduction of cultural development, etc. In general, the consequences of the development of smart infrastructure depend on the adoption of multifaceted and at the same time effective decisions.

Smart cities are considered as a model of urbanization in the 21st century and, accordingly, the issue of socio-economic aspects and implications of public management of smart infrastructure is of particular relevance. A smart city project must take into account a variety of aspects: from human behavior to the management of resources and infrastructure. Only the correlation of these components will make it possible to develop a really working concept, the emergence of which is impossible without a developed system of strategic public administration.

## LITERATURE REVIEW

Today, there are many examples of building smart cities. Indeed, visitors to Singapore often say they are living in the future – this is a sentiment shared by respondents to a 2017 Philips Lighting SmartCitiesWorld survey that named the tech-centric Asian city the "smartest" city in the world. One respondent noted: "The city demonstrates good examples of "forward-thinking" infrastructure: smart transport, buildings, underground pedestrian malls and smart environments" (Kumar *et al.* 2022). The city collects data on almost every aspect of daily life: it is equipped with a multitude of cameras and sensors that monitor everything from traffic to air pollution levels. Successfully implemented "smart" traffic lights and a "smart" parking system have completely eliminated the problem of traffic jams (Kryshtanovych *et al.* 2022).

In New York the most developed smart city in the USA local authorities have launched automated systems and applications to improve traffic. It appeared possible to partially solve the problem of large traffic jams and establish a system of using parking lots in specially designated places. Such a smart solution contributed to the development of bicycle transport: people got the opportunity to freely get to the necessary locations in conditions of heavy traffic on highways.

In developing countries, smart cities play a different role, responding to problems arising from population growth, climate change or migration. Smart cities in developing countries are often created "from scratch" instead of modernization of existing ones. For example, India has pledged to create 100 new smart cities, allocating £760 million to the project (Dameri, 2017).

In Hong Kong, AI technology is used quite widely in manufacturing, logistics, utilities, and construction. There are platforms for analyzing and responding to adverse climatic conditions, water accounting and increasing energy efficiency, reducing household waste and minimizing $CO_2$ emissions (Kryshtanovych *et al.* 2022). Digital technologies are quite widely used in city hospitals in order to simplify the work schedule of medical personnel and the procedures of processing and issuing documents.

One of the OECD reports defines the modern typology of smart cities (OECD, 2020):

*By type of smart city innovations*:

- Technological smart-cities are based on the values of technology when developing new practices and services (for example, applications that encourage the use of public transport)
- Organizational smart-cities focus on positive changes in the daily activities of local self-

government bodies (their efficiency and productivity)

- Joint smart cities focus on cooperation between various entities of the city city government, higher education institutions, business community. An open and interactive management process is a prerequisite.
- Experimental smart cities focus on a people-oriented approach. Their goal is to achieve holistic sustainability through the combination of the previous three types of smart cities.

*By the purpose*:

- Smart cities equipped with developed infrastructure and focused on efficient management. Investment is directed to the process of integrating ICT into the physical infrastructure
- Smart cities which are platform-oriented and focused on the connection and integration of information systems that previously functioned independently of each other
- Smart-cities focused on the creation of an innovative space and focused on the implementation of advanced technologies and commercializing them for the development of related industries.

It is also proposed to distinguish the following types of smart cities by purpose:

1. Aimed at the implementation of cost-effective solutions. Implementation of individual options for solving problems of urban development, use of "living" laboratories and exchange of solutions through networks.
2. Aimed at creating and maintaining innovative ecosystems for industries. The main methods are deregulation and the creation of a digital infrastructure based on open data platforms for industries (Macomber, 2016).

Projects that need to be implemented have an extremely serious monetary dimension and tight deadlines and have a priority in standardization. After the introduction of the concepts of smart city, smart grid, smart water and others into the field of standardization, the era of digital railways and digital industries has come, and the expansion of the list of such projects is inevitable; all these areas create their own ecosystem of standards, which are sometimes quite difficult to understand.

In the infrastructure projects, this led to the first attempts at generalization and the emergence of the term "smart infrastructure", understood as the result of combining physical infrastructure with digital infrastructure, providing improved information for faster and cheaper decision-making (Gaman *et al.* 2022).

The term "smart infrastructure" is used in different contexts to describe different socio-economic and technical conditions. Today, there is no single, universally accepted definition of smart infrastructure, nor defined norms and standards for its design and construction (Novak *et al.* 2022). This creates dualism, weakness of interpretation and slows down the process of building such an infrastructure. The lack of uniform standards has an ambiguous effect on the implementation of infrastructural smart projects, since the expectations of asset owners or operators of technological implementation of the so-called "smart" decisions may not be justified. Some authors define smart-infrastructure as a process of transition from the state of "unintelligence" to the state of "intelligence". An "unintelligent" infrastructure is not able to adapt to changing needs, while a "smart" one can increase productivity by purposefully responding to changes in the environment and to the requests of users (residents). Smart infrastructure involves the transition to positive changes in the provision of various services thanks to the introduction of technological innovations (Kalyayev *et al.* 2019; Kryshtanovych *et al.* 2021). At a basic level, smart infrastructure can be defined as an interconnected network that provides digital information about the state of the system in real time. This definition focuses on the system's ability to self-monitor through a combination of physical assets and digital technologies. In this context, digital technologies are used to capture data, which are then processed, stored, and transmitted as reliable information to assist infrastructure service providers in making informed decisions regarding the management of their infrastructure assets (Mehmood, See, and Katib, 2019).

Data-driven technologies can help integrate urban systems into a more efficient, sustainable system, for example by "linking" real-time data on traffic

flows, electricity supply/consumption, water supply, and waste. So, for example, "smart" meters and dynamic electricity pricing can significantly change the energy consumption patterns of enterprises and households. Electric cars, bicycles and scooters can significantly reduce air and noise pollution. Overall, smart infrastructure can make a significant contribution to the development of a circular and carbon-neutral economy. The development of such infrastructure can facilitate a more flexible model of city governance through e-government services and technologies to ease access to information and expression of opinions through Internet platforms. Through such platforms, participation in budget formation becomes possible: citizens become aware of the direction of local budget expenditures (including infrastructure projects and programs). Digitization of infrastructure will provide cities with an opportunity to strengthen organizational and administrative potential in order to overcome bureaucracy and improve human resource management practices. Early warning systems for natural disasters can improve preparedness for their occurrence (and, accordingly, their consequences) or prevent them.

The most studied, in the above sense, were smart cities, which are represented by almost all the infrastructure that people use today. Infrastructures (both physical and digital) are assets (Novikova *et al.* 2021). The introduction of these concepts allows considering the main thing the economic efficiency of certain innovations introduced into practice. Namely these economic calculations make it possible to determine what then refers to disruptive technologies in the digital economy, to which we include the great technologies of the 21st century BIM, GIS, Smart Cities, IoT, robotics, and many others.

In a digitally transformed world, the most complex topic (in people-centred solutions and social impacts) is the most infrastructure-rich one, namely such as "Smart Cities". Today is a turning point in human development: success or failure will be 'decided' in cities, but more than 80% of the world's cities show signs of fragility, and success or failure in them will solve the world's most pressing problems. Cities have reached tipping points on many issues: poor governance and weak institutions (the first perceived obstacle to prosperity); inadequate infrastructure ($78 trillion investment are required over 10 years); growing social inequality (75% of cities have become worse than they were in this part 20 years ago); places to live are needed (1 billion new medium-sized houses need to be built in cities); growing crime (the main concern of citizens); growing environmental problems (about 75% of the use of natural resources go into emissions, and cities are the main consumers of natural resources and the main polluters of the planet); new and pervasive risks for cities (cybersecurity breaches, terrorism, securitization, disease and pandemics, etc.). Infrastructure plays a key role in addressing many of these challenges, which was understood already a decade ago (Caragliu and Del Bo, 2012).

According to futurologist Frey (Frey, 2011: 32), the development of e-government technologies will become a global trend: municipal services related to procedures, regulations, and licenses will finally become digital. The second important innovation will be a public interface that provides maximum openness of data. There will be thin threads connecting large processes and small ones, household municipal services and citywide computer management systems (Litvinova *et al.* 2020). Through the Internet and the development of personalization technologies, the capabilities of the network have become adaptive: search engines and social services, analyzing the history of people network activity and calculating their location, give increasingly accurate recommendations on a huge range of domestic, personal, public, and business issues.

Awareness of the significance of social and architectural data about the space of the city became the key idea of the new urbanism in the concept of Jan Gale, who founded a company for the smart organization of urban space and the creation of cities for people by observing the behavior of residents and collecting information about them. The idea of the existence of affective connections between people and the environment is expressed by Tuan Yi-Fu in the term "topophilia" (Suzuki and Finkelstein, 2019), meaning such a union of culture and environment at the level of the city, suburbs, countryside, and wildlife that forms the values of residents.

As the concept of smart cities has developed, its criticism from the scientific community has grown.

A number of researchers note that the development of the smart city concept was strongly associated with the flourishing of IT technologies, the Internet, mobile applications, high-tech centralized control systems capable of solving all urban problems, but the problems of cities and the population were completely lost from the context (Khomiuk *et al.* 2020).

An analysis of studies on smart cities allowed us to identify several key positions that are most often criticized. First of all, one should note the problems of social inequality, exacerbated by the digital divide. Most researchers say that modern information technologies contribute to the acceleration of economic growth, the prosperity of cities, as well as social stability (Hsiaoping, 2017; Scott, 2016). However, a study by McKinzey (cited in Woetzel and Kuznetsova, 2018) critically assesses the economic effects of the implementation of individual smart city solutions, and also provides a list of the most and least popular solutions for citizens. It follows from these data that the share of smart solutions users among the adult population of the largest cities in the world does not exceed 52%, and awareness of existing smart solutions ranges from 36 to 72%. It is obvious that the availability of IT technologies does not always mean that they can be mastered and used by all residents, and the principle of inclusion declared by smart cities in practice very often remains an illusion and is a reason for criticism (Panasiuk *et al.* 2020).

The authorities of most countries tried to promote the idea of a "city of the rich" or "city of entrepreneurs", for which urban infrastructure was created and modernized, expensive business centers and hotels were built, while the social problems of the poorest strata remained unresolved. As a result of such a policy, there was an increase in the social, economic, and cultural polarization of society. Such stories can be clearly seen in cities such as Singapore, Sao Paulo, Kuala Lumpur, Bangalore, and others, where despite huge investments in the development of information infrastructure, high levels of poverty are preserved and social problems remain unresolved (Annansingh, 2021; Visvizi and Lytras, 2019).

Of particular interest is the study of Scott (2016) on Seattle's experience in building a smart city. Seattle has used the smart city concept to address racial, social, and economic inequalities through digital inclusion, by providing greater access to the Internet. In practice, it turned out that the smart city technologies used were more focused on ensuring city safety and crime mapping, as a result of which social inequality only increased, the problem of institutional and structural racism worsened, and the number of cases of racial segregation increased (Scott, 2016).

Many experts agree that a number of smart infrastructure projects contain too much "technology for the sake of technology", some innovations are inappropriate or unnecessary, their implementation does not take into account the interests of citizens, although the implemented smart technologies should have been used primarily in the interests of residents (Barns, 2018).

There are a number of other studies regarding the technological limitations associated with the implementation of the smart city concept. As it is known, the implementation of this concept is associated with ITos, 5G (Chevrette and Ellermeier, 2018). In the work of Routray *et al.* it is said that city managers very often make unrealistic promises to citizens about the benefits of creating smart cities, while the technological limitations associated with their implementation are not taken into account (Routray *et al.* 2019). As a rule, when implementing the concept in cities, politicians suggest using the latest technologies, the effectiveness of which is too exaggerated, while not taking into account several important factors, such as the capacity of the city's infrastructure, systems and services serving it, and, as a result, cities have lower performance indicators of systems used than planned. In addition, often the costs of implementing smart city programs are not fully taken into account when approving city budgets, since they are initially understated and, as a result, budget expenditures do not cover the real value of the costs of implementing these programs (Routray *et al.* 2019). The fact that most smart city projects and technologies do not bring large incomes in the first years is not taken into account. Most of the solutions offered by IT companies today are fragmented, so the largest companies in the world, such as Google, IBM, Microsoft, are developing all kinds of integrated solutions that connect all verticals on one platform, which also leads to an increase in the cost of the final product.

Modern researchers are asking the most important question about the future of modern cities: what is the place of a person, a human in this technically equipped and environmentally sustainable city? The smart city concept declares citizens as key beneficiaries of ICT investments, but at the same time considers them as passive beneficiaries (Panasiuk *et al.* 2021).

Meanwhile, the basis for creating a smart city that is, first of all, smart infrastructure should be a smart economy, the main goals of which are to increase the efficiency of the functioning of urban economies, competitiveness, and achieving sustainable growth through human capital, a reasonable combination of technologies, resources, and management tools. This theoretical concept, while being embodied in the reality of cities, faces many problems that can be solved by increasing trust, solidarity, and interaction of all stakeholders. Thus, it is obvious that the subjects of public management of smart infrastructure face the most difficult tasks that require a systematic approach to their solution.

## MATERIALS AND METHODS

The theoretical foundation of the research is based on the system and activity approaches, the concept of the information society. The systematic approach made it possible to reveal the features of the digitalization of public relations and the management system, highlight the goal, determine the subjects implementing these changes, their functions and relationships with other participants.

The theoretical basis of the study was the works of the authors on the problems of sustainable regional and municipal development, current theoretical and methodological approaches to the study of the nature, features, and possibilities of managing spatial and economic transformations of smart cities infrastructure, works devoted to promising areas of digital transformation and the growth of digital maturity of municipalities and agglomerations, reserves for increasing efficiency.

The set of methods of scientific research and knowledge used in the article is represented by a system of general scientific, general economic and special research methods, methods and developments in terms of regional and municipal economic measurements, monitoring of crisis problems and situations (Gupta *et al.* 2021). Among the research methods, there is also a logical analysis of modern approaches to assessing the development of smart cities.

## RESULTS

Today, global spending on projects in smart cities is growing at a very fast pace (Fig. 1):

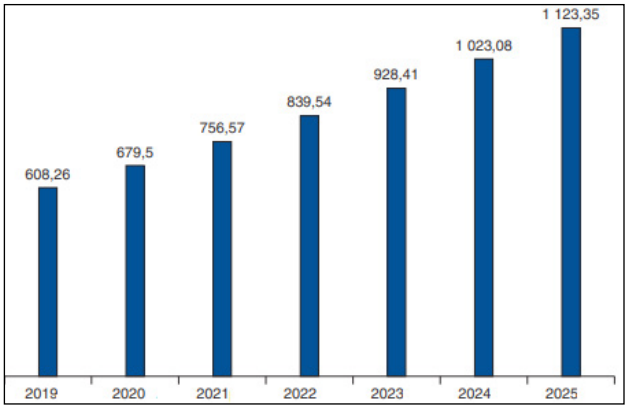


**Fig. 1:** Global costs for projects in smart cities (including forecasted ones), $ billion (Kumar *et al.* 2022).

The global smart cities market size was valued at USD 1,226.9 billion in 2022 and is expected to register a compound annual growth rate (CAGR) of 25.8% from 2023 to 2030 (Grand View Research, 2022). U.S. smart cities market dynamics is quite indicative of the whole trends (Fig. 2):

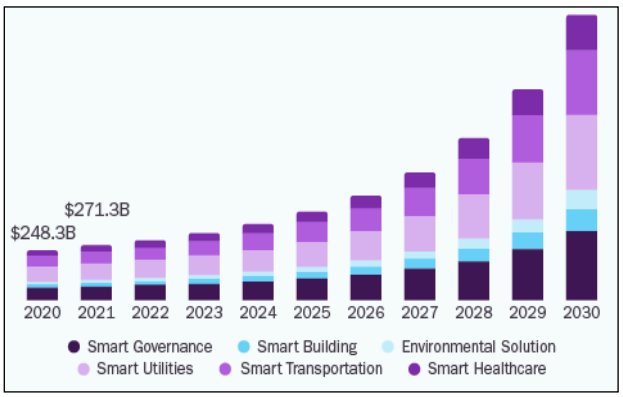


**Fig. 2:** U.S. smart cities market size, by application, 2020-2030 (in USD billion) (Grand View Research, 2022)

Today, the first pilot projects of smart cities demonstrate the "brilliance and poverty" of super intelligent technologies, the power and weakness of the largest international corporations. Giants such as IBM, Microsoft, General Electric, Siemens have invested billions of dollars in creating new cities from scratch and even on artificial land. The question of whether a person would like to live in such a

high-tech world was not particularly interesting for the designers and investors of these cities: they hoped for advertising and information campaigns. As a result, crude blueprints for technocratic utopias began to materialize, accompanied by bustling glossy advertisements, urban forums, and a series of commissioned magazine articles celebrating the "brave new world" of cities of the future (Visvizi and Lytras, 2019).

When the first cities were built, it turned out that citizens were in no hurry to populate them. Many modern urbanists note with great irony that these glittering new smart cities monuments of human ingenuity and will Songdo in South Korea, Masdar in the United Arab Emirates, Konza in Kenya, Palava in India, unfortunately, are at risk of remaining monuments, lifeless symbols. In 2017, the fully completed Songdo was only half populated; the unfinished Masdar is also sparsely populated; Konza and Palava are empty.

There are quite enough of reasons for this. On the one hand, it turned out that technological solutions in the field of centralized management of the smart city communications system were not well thought out, and feedback from consumers was not provided. As a result, the automatic control system cannot cope well with abnormal situations that constantly arise in a complex urban environment where hundreds of people intersect (Gupta *et al.* 2021). For example, if a guest or tourist who has arrived in such a city does not have a specific application on his smartphone that provides access to buying tickets for public transport, he will not be able to go anywhere: there are no ticket offices in the city.

On the other hand, serious social and psychological problems emerged. Some do not want to live in such a city, because they do not have enough education and funds to buy an apartment or house there, even on credit terms, and to constantly buy ultra-modern gadgets and software for all family members (this is the phenomenon of "electronic inequality"); others do not like the lack of cultural and historical traditions, absence of the possibility of meaningful cultural communication in the centers of high culture theaters, concert halls, exhibitions and museums (they will never be completely replaced by the so-called digital culture), and the nearest cultural center is far enough away; many are oppressed by the monotonous primitive constructivist architecture of such cities the source of depression; some categorically refuse to live near the office, constantly rotating in the circle of the same people (new cities are small and compact); and everyone lacks attachment to the territory, a sense of the unity of the local community, which do not arise from scratch.

Today, more than ever, competent public administration in order to address the dead ends of the technocratic project of the smart city is important. The main lesson of the implementation of the first experiments in the construction of smart cities is that modern urban studies must learn to think in the paradigm of synergetics, creatively combining the achievements of both technical and human sciences. Urban planning should be the collective creation by a community of experts from a variety of fields. While earlier it was only economics, architecture, land use, construction, engineering communications, today it is also anthropology, sociology, psychology, philosophy, political science, communication studies.

Establishing effective data collection requires city governments to build partnerships with key information providers. Also, public authorities and local governments should enlist the support of the population in the implementation of initiatives based on data. The support of the population will significantly increase the effectiveness of managerial and organizational decisions, give legitimacy to the decisions, and give the city the image of a modern and convenient place to live. Technological infrastructure solutions chosen by the city should improve the information interaction of all stakeholders in an optimal way, as well as help to choose the forms of implementation of electronic participation and involvement of citizens in the planning and implementation of urban infrastructure initiatives.

In some cases, in the absence of economic progress in infrastructure management, organizational decisions are already being made. In particular, in Norway, at the start of the creation of a digital railway, a management reform was carried out throughout the country's railway network. The aim of the railroad reform was to make the daily use of this transport easier for individuals and businesses. The goal of the reform was also to create

greater predictability and a clearer distribution of responsibilities in the railway sector, as well as its adaptation to competitive bidding in passenger services. When the Norwegian parliament decided to support the reform proposed by the government, a new state-owned company was founded in February 2016 as the successor to Jembaneverket (Norwegian National Railway Administration). This company has been named Bane NOR SF and has been fully operational since January 1, 2017. The Directorate of the New Railway, responsible to the Ministry of Transport and Communications, was created at the same time (Kulikov *et al.* 2022).

Data is at the heart of the digital rail program and its intellectual assets. Creating one common set of data will allow supporting multiple types of business, including operations such as asset management, operations management, scheduling, and signaling. This required such radical measures in Norway. Digital rail programs will be consistent with the processes and philosophies of the new decision support tools that are being rolled out on the railroad. In the new Bane NOR SF organization, the important interfaces will be clarified, that will be needed to deliver information to businesses and consumers, recognizing both the value and importance of data for a wide range of applications including asset management, schedule production, and passenger information and management (Gavkalova *et al.* 2022).

Ultimately, in order to achieve improvements in the information and maximize the benefits of available data, a clear industry data strategy will be developed and adopted with the participation and agreement of each stakeholder, including government, railway operating companies, supply chain, and other network operators. With data comes responsibility. The opportunity for open source data to drive innovation must be weighed against the need for security and regulation to ensure data is up to date, accurate and secure.

Regarding the concept of smart city government, Meijer and Rodriguez (2016) identify four ideal typical city government models: (1) smart city management; (2) "smart decision making"; (3) "smart administration", and (4) intelligent urban cooperation. These concepts reflect different theoretical views on the role of government in modern society.

The first type, smart city management, assumes that there is no need for digital transformation and restructuring of government structures and processes. In this model, "smart governance" is the application of human intelligence in making "correct" political decisions and their effective implementation (Alkandari, 2012; Nam, 2012).

The second type of governance, "smart decision making", highlights the need for smart decision making processes based on the use of better (more full) information in government decision making and their implementation (Kourtit, Nijkamp, and Arribas, 2012).

The third type of governance, "smart administration", is governance using a specialized form of e-governance based on sophisticated information technology, integrated information resources and technically advanced infrastructure for connection and process, and to better serve citizens and communities. This type of smart governance requires a restructuring of the government's internal organization: an innovative administration that meets the demands of differentiated policies (Visvizi and Lytras, 2019).

The fourth type of governance, smart city cooperation, represents to the most extent public aspects of governance, a kind of "smart city cooperation" between different actors in the city. Spanish scientists attribute this model to the highest level of transformation, since it is not only about the transformation of the internal organization, but also the external organization of relations. Scholars emphasize that "smart governance" is active and unbiased governance structures, in which all actors participate, to maximize the socio-economic and environmental performance of cities, which confirm that the city is coping with negative externalities (Dameri, 2017).

Meijer and Rodriguez conclude that one aspect of smart public administration is expressed by the legitimacy component, decision-making focuses on strengthening the legitimacy of urban governance through better policy outcomes in terms of welfare, health, and sustainable development, while others focus on strengthening citizen participation and open forms of cooperation.

Two perspectives emerge here: the first is a focus on the content of government action as a source

of government legitimacy, while the second perspective emphasizes the governance process (Mehmood, See, and Katib, 2019). Issues of power and democracy play a key role in publications that focus on gaining legitimacy for urban governance through smart city as a process. This perspective emphasizes the active participation of citizens and stakeholders in urban governance. However, this kind of interaction is hardly political in its nature.

In terms of legitimacy as content, many publications emphasize that governments should develop technology roadmaps to support research and development of future public sector technologies and services that could improve the quality of life of citizens to increase government legitimacy (Akimova *et al.* 2020). In addition, governments should develop a public subsidy plan to promote smart cities in infrastructure (water supply, electricity systems, transportation systems, urban infrastructure), education, healthcare, and innovation. The emphasis is made on both material output (wealth) and post-material output (health and sustainability), as well as the social integration of city dwellers into public services. Scientists argue that the idea of a "smart city" can contribute to the legitimacy of urban governance through strengthening results, including through sustainable economic development, the development of more democratic forms of government, in particular, the direct participation of citizens in governance (Deyneha *et al.* 2016). As a result, scientists come to the conclusion: the current debate about the management of smart cities is rather confused, since there are many different points of view on smart cities and smart management. This confusion can be productive when the variety of approaches is based on organizational principles (Kim, Sabri, and Kent, 2020).

Meijer and Rodriguez provide some guidelines for smart city management research (Meijer and Rodriguez, 2016):

- It is necessary to conceptualize smart city management as an emerging socio-techno-practice;
- It is worth focusing both on the transformation and on the preservation of the institutions of urban management;
- It is necessary to evaluate the contribution of smart city management both economically and socially;
- There is the need to analyze smart city management policy more carefully.

In conclusion, the scientists emphasize that it is worth studying smart city management as a complex process of institutional change and taking into account the political nature of the concepts of socio-technical management (Levytska *et al.* 2022). This means that policy makers must understand that technology alone will not make an infrastructure and the city as a whole smarter: building a smart city requires a political understanding of technology, a process-based approach to managing an emerging smart city, and a focus on both economic benefits and other social values.

The second approach to studying the concept of "smart governance" is presented by Jiang, Geertman, and Witte (2020) from the State University of Utrecht in the Netherlands. They view it from different perspectives: (1) "smart governance" is about making the right policy decisions and implementing them effectively and efficiently; (2) "smart management" the development of innovative management structures using new technologies and new communication channels.

It should also be noted that "smart management" in the field of urban planning is result-oriented, that is, directly solving the problems of the city. Reflecting on the versatility and fragmentation of this concept, scientists refer to the above-mentioned researchers Meyer and Rodriguez (authors of the first approach), who summarized four typical ideal conceptualizations: smart city management, smart decision making, smart administration, and smart city cooperation (Karpa *et al.* 2021). Scholars agree with this typology and definition given by Meijer and Rodriguez, who say that smart governance "consists of creating new forms of human collaboration through the use of ICTs" for better outcomes and more open governance processes (Annansingh, 2021).

Jiang *et al.* emphasize that "smart governance" creates an infrastructure to ensure the continuous functioning of the city's governance system and shapes an environment for cooperation and

communication, the involvement of citizens (Troschinsky *et al.* 2020). To support their point of view, the authors refer to the example of Urban Living Labs in Amsterdam, where several stakeholders work together to develop solutions to complex urban problems. Dutch scientists believe that "smart governance' and "smart management" as its component supports the creation of innovative learning, as the widespread use of computing technologies eliminates restrictions and reduces time costs.

Almost all approaches take a socio-technical view, according to which, for the development of "smart management" in the city, it is required to include in the infrastructure technologies for public participation of citizens in city management, that is, from the point of view of the socio-technical approach, it is necessary to study and implement management support systems, combine ICT with human resources. An example of such an approach is Shenzhen's smart city structure (Fig. 3).

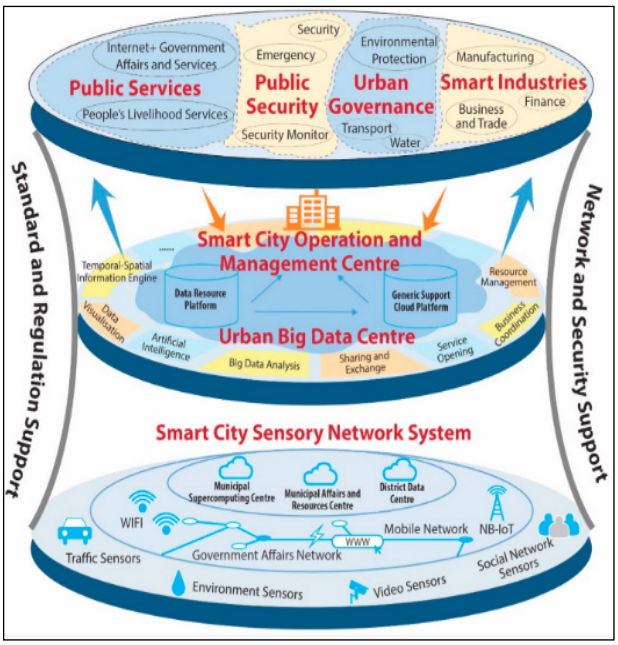


**Fig. 3:** Shenzhen's smart city structure (Hu, 2019)

Naturally, the important positions that determine the functioning of the model are the current state of the institutional 'picture' of society, as well as the level of regulatory landscape, the degree of "pressure" of business and civil society on government, the level of development of civil society institutions, the quality of human capital, and other factors.

## DISCUSSION

Efforts to plan for a smarter urban environment are multisectoral, interorganizational, and intergovernmental. This implies bringing together people from different walks of life with different skills and competencies. Many researchers believe that cross-disciplinary teams should be brought together to address the organizational rigidity and division of labor that characterize the public sector (Suzuki and Finkelstein, 2019). The creation of inter-organizational and interdisciplinary teams seems to be the most appropriate solution for implementing complex planning focused on various social groups, touching on the problems of shared resources, budget cuts and the prospect of low profits that characterize smart cities (SC) projects.

Experts argue that a public manager must possess a "skills triangle" that consists of three different types of competencies: technical, leadership, and ethical (Yigitcanlar *et al.* 2018). As T. Virtanen pointed out back in 2000, competencies are mainly discussed in relation to qualifications. The author draws attention to the fact that in modern public administration, qualifications are mainly associated with the doctrine of the New Public Management (NPM), and identifies 5 areas of competence (Virtanen, 2000: 335-340):

1. The competence of the task, i.e., the ability to set tasks and achieve set goals, as well as to know how and why a task should be completed (task competence is the most concrete (specific) of all areas of competence, because, as the author notes, "the ends and means are given, and the task simply has to be completed" (Virtanen 2000: 335);
2. Competencies in the professional (subjective) field of activity;
3. Managerial competencies;
4. Competencies in politics (values, ideology, and power);
5. Competencies in matters of ethics (related to moral values and norms). Without competence in matters of ethics, public managers cannot use their professional or political competence in the right direction.

At the same time, according to the author, it is important that each area of competence contains

both a value and an instrumental component, while in the subject literature competences are mainly understood in a technical or instrumental sense (Virtanen, 2000: 338).

This distinction is important in the context of defining the competencies of a public sector manager.

In turn, M. Noordegraaf rightly notes, on the one hand, that state (public) managers are competent in those situations in which they know how to apply the rules. On the other hand, public managers in the performance of their work are forced to operate in conditions of uncertainty and ambiguity. At the same time, ambiguity is understood as "a contradictory interpretation of what is necessary, possible and needed to do, when and where to do it" (Noordegraaf as cited in Ruhlandt, 2018).

In such ambiguous situations characterized by uncertainty (namely such as questions related to SC), public managers are deprived of the opportunity to choose the best option and are forced to act more by trial and error and using heuristic approaches. D. Forester connects uncertainty and ambiguity with the instrumental and communicative concept of public administration and planning (Forester as cited in Kumar *et al.* 2022). If governance is seen as "solution to problems independent of context", the emphasis will be made on reducing uncertainty "based on common sense". On the other hand, if the managerial action is context dependent, the elimination/reduction of ambiguity and uncertainty is achieved through the communicative processes of dialogue, argumentation, and social learning.

Let us mote that issues related to the competencies of public managers who operate in a specific environment characterized by ambiguity and novelty (such as the field of SC) are insufficiently explored in the literature on public administration.

A breakthrough in this direction was made by a team of researchers who identified 5 main categories of required competencies for an SC manager. These include (Michelucci, De Marco, Tanda, 2016):

1. Urban planning capabilities (urban innovation, spatial planning and management of urban facilities, skills related to the development of strategic, long-term planning of sustainable urban services);
2. Legal competencies (legal concepts related to Big Data / open data management, data security, legal aspects of public procurement and contractual issues related to public-private partnerships);
3. "Soft skills" (empathy, flexibility, result-oriented and open-minded behavior, the ability to mediate conflicts and create relationships, strategic vision, skills in project management and leadership qualities);
4. Management of financial resources (instruments of public financing, new financial instruments, general knowledge of economic fundamentals);
5. Basic capabilities (acquaintance with ICT, knowledge of foreign languages and past professional experience).

The interdisciplinary position of the SC manager is also indicated by the answers to open-ended questions given by some respondents in various studies, which listed various combinations of required competencies.

The concept of an open access order implies the equality of citizens, the democratic nature of the state, and the impersonality of service provision (Yigitcanlar *et al.* 2018). The first two criteria are enshrined in the constitution, but it is worth talking about impersonality only with a high degree of development of political institutions. Michel Foucault emphasized the importance of relationships that exist independently of individuals, i.e., the formation of high-quality political institutions where the human factor is minimal (Suzuki and Finkelstein, 2019). Undoubtedly, the spread and availability of technical means of accessing the Internet expands the possibilities of meeting needs in a much shorter time and with less effort. The expansion of resource opportunities leads to a global transformation of relations, positions, functions and structure of social institutions.

Namely the impersonality stimulates the flexibility of institutions, the quality of the organization of which is measured by the ability to function without being tied to the personality of an official. Technology is becoming a fundamental means of implementing an open access policy and helping to reduce corruption factors. According to the logic of Michel Foucault, through the use

of technology, mass public participation in power decisions is possible, which contributes to the decentralization of management. The above tools for the institutionalization of the use of technology have a wide development potential in the qualitative restructuring of the model of interaction with government agencies and, at the same time, carry certain risks that may manifest themselves if government organizations are not ready to quickly respond to changes. This will contribute to their institutional evolution.

Moreover, it is important to involve large companies in the development of urban infrastructure, equipping it with less energy-intensive means of transport, using the latest materials for road construction involving city data to adapt urban recreational areas and business centers. Such measures are long-term investments, since more productive enterprises require fewer human resources, but are more profitable, which allows investing in the development of urban space.

Thus, urban policy becomes a joint activity, in which co-participation in the development of infrastructure, in the creation of favorable conditions for doing business, in caring for residents and social guarantees is inevitably realized. Citizens are involved in the system of urban functioning, but their political role in the management of such cities is not defined, since the role of investors in the development of technologies increases, which leads to the management of global corporations at the local level. Local government positions can be preserved by making it the center of urban data analysis; the government in smart cities is undergoing institutional transformations driven by the publicity of all administrative processes. A smart city is a competent mechanism for launching economic growth at the state level; its creation requires ensuring a fundamental transformation of priorities through the publicity of city politics and the removal of bureaucratic barriers. Such transformations are based on: awareness of responsibility for the well-being of city residents; long-term planning and monitoring of achieved results; the ability to flexibly implement changes using analytical technologies, and greater involvement of citizens as users and as participants in public policy.

Public management of the city assumes that investments in human and social capital, communication infrastructure are aimed at sustainable environmental, social, and economic development and improving the quality of life, and are also associated with a well-thought-out resource management system and mechanisms for citizens to participate in the development of the urban environment – the overall infrastructure which is designed for citizens' real needs and aspirations. At the same time, public management of the city can be understood as the organization of interaction between government, society, and business in order to create a comfortable urban environment. This process cannot be vertical and must be carried out through stakeholder groups that play an important role in the implementation of specific areas and initiatives of local communities. Firstly, these are the authorities of the regional and local levels, in whose hands a powerful administrative resource is concentrated in the field of regulating urban life. Secondly, these are representatives of the business environment companies that develop and implement smart solutions in the urban environment, that is, those that allow the systematic application of existing innovative technologies in specific areas of urban life (for example, energy saving, healthcare, finance, transport, etc.). Thirdly, these are urban communities (communities of citizens), which are an important source of initiatives in the field of decision-making on the problems of the urban environment. Among the latter, experts play the most important role: they act as representatives of the very creative class that is the driver of the development of a modern city. They form the strategic vision of the future, designate the key priorities for the development of urban space.

Urban strategies based on the collective formation of the future are called foresight technologies. Their application in public administration is associated with the need to determine a strategic vision of how to make the city attractive for life and what exactly should be a comfortable urban space in the future (Annansingh, 2021). Foresight in relation to urban management is an adequate way to form the image of a modern, comfortable city, which is created through the interaction of all stakeholders of the urban space. In other words, if we are talking about the public management of a modern city, then with the skillful use of foresight, a favorable climate is created for a constructive dialogue between all

stakeholders on priority areas of development in the medium and long term.

The concept of a smart city can also be extended to aspects not related to the operational management of the city. A digitally driven economic and social development approach is often used to stimulate growth, solve social problems, and preserve and develop culture. At the same time, existing cities with historically developed infrastructure and administrative systems require a more moderate phased approach to modernization. Several key areas where transformations contribute to the development of a smart city can be distinguished: management model, financing, business models, smart city services, technology, smart city communities, institutional environment. The idea of how a smart city should be built and managed is moving away from the traditional closed and top-down approach towards a more open, networked model.

Currently, studies of the innovative paradigm of urban policy are interrelated with environmental, social, economic, demographic, and technological problems. There are several levels that make up a smart city and characterize the degree of its development (Suzuki and Finkelstein, 2019).

1. The level of urban infrastructure. At the heart of any urban economy, there are traditional components that are present in every city. Urban infrastructure (engineering networks, roads, transport) is the basis for the development of smart cities. It is also important to note the role of citizens in the development of infrastructure, as new construction often affects the existing historical heritage, putting it at risk.
2. Institutional level. In recent years, there has been an increase in the number of studies that note the institutional component as the main reason for socio-economic development. Institutional development, like technological development, includes both an innovative and an imitation component. The main task in this case is to choose a trajectory a sequence of institutions that meets certain requirements and has a chance of success.
3. Ecological level. Modern theories of urbanization pay considerable attention to the issues of ecology and environmental protection in the development of the urban economy. A layer of green urban infrastructure creates a favorable environment for the formation of sustainable development principles. Urban planning raises questions about the priority of green city objectives, which require innovative forms of environmental management, policy integration and financial resource allocation to develop an appropriate mix of green urban ecosystems.
4. The level of information and communication infrastructure, uniting the urban economy into a single information space. Digital infrastructure, broadband communication strengthen the economic potential of the city and increase social cohesion through holistic coverage of the urban area. This level directly indicates the ability to support innovative infrastructure and telecommunications to connect people and technical devices in order to provide high-speed network access throughout the city. City governments must address the issue of broadband coverage throughout the city, including underdeveloped areas.
5. Data layer. Cities as real-time systems require a reaction to events. For this, real-time digital devices such as RF transmitters, traffic signals, smart meters, infrastructure sensors are used. In fact, the availability of real-time data is an integral element of smart cities that connect the physical world with the information world, and is a hallmark that justifies the definition of "smartness".
6. Level of integration. Smart city applications must be able to interact and share data. A key success factor for intelligent environments is the provision of an open and distributed repository of information for all systems implemented on different technology platforms. Smart city platforms visualize urban space, collect data, and implement intelligent applications. Internet development trends are catalyzing smart city interoperability, opening up new opportunities for web services through connected and open data. The ability of a

city to moderate, integrate, and open access to intelligent digital resources is an important process for city monitoring.

7. Application layer. At the application layer, web-based solutions are implemented that provide intelligence possibilities and optimize the use of resources when processing real-time data streams.
8. The level of development of human capital. Human capital is becoming the most important condition for the formation and development of a smart city due to the fact that only highly educated residents are able to create and use intelligent solutions in the development of the urban environment.
9. Level of innovation. Smart cities create a favorable innovative environment for new opportunities. To do this, firstly, it is necessary to change the quality and efficiency of state structures. Secondly, a smart city should be an attractive place to do business. Emerging technologies require an innovative environment, to accelerate the path to sustainable prosperity using new solutions and management methods.

Stakeholder collaboration in urban development creates new business opportunities that will ensure the long-term viability of smart city projects. Business models should take into account the involvement of participants, their functions, technological capabilities, funding issues, and other areas. Such interactions lead to new networks and strategic alliances from project-oriented individual collaborations to collaborative strategic partnerships. While there is no single approach to address urban issues, even with regard to seemingly similar topics (e.g. water, energy, and environmental degradation), a conglomeration of diverse actors is beginning to form an overarching framework for conceptualizing the urban smart city innovation ecosystem. One of the most important requirements for the development of a smart city is economic, political, ethical, and legal sustainability, which means that the actions of the authorities must maintain a favorable infrastructure throughout the ecosystem. In addition, access to this infrastructure is important.

## CONCLUSION

Rapid urbanization creates risks and opportunities for smart development. Urban policy and decision makers are confronted with the increasing complexity of cities as socio-environmental-technical systems. Consequently, there is a growing need to co-develop principles that support the overall resilience of the system and enable transformational changes at various scales in order to adequately respond to the changing situation. Such holistic urban approaches are rare in practice. Research in the field of systemic digitalization of the urban environment identifies a set of measures, usually reducible to three stages: (1) the formation of a common structure to support the more systematic development and use of knowledge, (2) the identification of barriers that create a gap between the declared urban goals and actual practice, and (3) identifying strategic target areas to address these gaps. The development of integrated strategies on a wider urban scale is seen as the most urgent need.

Consistently satisfying the basic motives of representatives of human and creative capital in terms of attracting, rooting, integrating, and interacting of the indicated groups of the population and labor resources of the municipality with the rest of the local community, the "smart city" can become a national and international point of labor and entrepreneurial mobility, where it is possible to achieve and enable the growth of competitiveness of the corporate sector structures, the achievement and maintenance of an effective socio-economic consensus between the stakeholders of the municipal space, the rationalization of environmental management and the qualitative transformation of the interactions "economic space - infrastructure - economic environment" in the direction of sustainable development and reducing the negative consequences of anthropogenic pressure and economic activity.

The conceptualization of the urban environment as a complex multidimensional or hybrid system is a key feature of research in this area, and understanding development as a set of nested adaptive cycles helps to understand the reasons for the changes and sustainability of urban systems in terms of effective public administration in order to achieve positive socio-economic aspects.

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