Annals of Spiru Haret University.
Economic Series
Since 2000
ISSN:2393-1795 ISSN-L:2068-6900

**Issue 4/2021**

# SMART CITY DEVELOPMENT BY SUSTAINABLE DIGITAL TRANSFORMATION*

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**How to cite:** IORDACHI, V. (2021). "Smart City Development by sustainable digital transformation." *Annals of Spiru Haret University. Economic Series, 21*(4), 267-277, doi: https://doi.org/10.26458/21414

**Abstract**

*Smart City concept is getting an increasing interest for municipalities representing one of the solutions for solving various city problems starting from urbanization problems and ending with environmental challenges. In these conditions, approaches to urban development management are gradually revised and are increasingly relied on advanced technological solutions, digitalization and platformization. Today, the digital upgrade of cities is becoming a central political choice for many countries, because it achieves, on the one hand, savings and efficiency in the operation of its services and in the management of its problems and on the other hand, speed and transparency in decision making. This paper aims to analyse the role of smart technologies in promoting sustainability and smart city concepts, as well as to establish a relationship between these two concepts. For these there have been applied methods of scientific investigation like analysis and synthesis of specific literature in the domain of circular economy, smart city, smart technologies, induction and deduction, critical analysis of materials. Sustainable development is based on the interaction of three aspects that are interdependent and mutually reinforcing. These are the economic, social and environmental aspects of a development. Thus, the circular economy concept*

* *This study was developed within the State Program 20.80009.0807.22 Development of the mechanism for the formation of the circular economy in the Republic of Moldova.*

Annals of Spiru Haret University.
Economic Series
Since 2000
ISSN:2393-1795 ISSN-L:2068-6900

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*can provide new, more impactful solutions to the smart city systems through new mobility, improving energy efficiency, smart environmental solutions.*

**Keywords:** *smart city; smart sustainable city; circular economy; Internet of Things; urban development; sustainable digital transformation.*

**JEL Classification:** O33, O44, Q55

## Introduction

As populations and urbanization rise in the coming years, many cities may turn to technology and advanced networks to help them manage resource constraints. Problems related to increasing economic and demographic pressures of cities in the modern world poses fundamentally new challenges for urban development. Growing migration, excessive density, transport problems, increasing environmental pressure, changing requirements of residents and businesses to the quality of the urban environment and services provided - this is just a small list of challenges that are faced by modern cities. In these conditions, urban development administration is gradually revising approaches to urban development management, which increasingly relies on advanced technological solutions, digitalization and platformization. Ideally, we are talking about the transition to an integrated digital urban ecosystem that would respond to emerging challenges, contribute to meeting the needs of all participants (residents, businesses, authorities, etc.), and would also provide a more effective integration of individual elements urban infrastructure. To conceptualize such a transition, the term of *smart city* is often used. This concept is interpreted broadly and in different ways, however, in any approach, the key role is assigned to information and telecommunication technologies that help most effectively ensure the current processes of city life and solve emerging problems through the involvement of citizens, business and authorities.

## 1. Smart City Development

The first mentions of the term smart city date back to the early 2000s [Sikora-Fernandez D., Stawasz D., 2016]. Since then, at the substantive level, this concept has undergone certain changes, but has not lost its relevance. The smart city concept originally described how IT infrastructure can be used to create a virtual city space in the information society [Ishida, T. Isbister, K., 2000]. At the next

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ISSN:2393-1795 ISSN-L:2068-6900



stage, the smart city was mainly associated with the strengthening of the role of smart technologies in improving the efficiency of urban development [Van der Meer, A. Van Winden, W., 2003]. Finally, today it is increasingly common to talk about a smart sustainable city (SSC), in which information and communication technologies and other tools, on the one hand, are used to improve the quality of life, the efficiency of the functioning of the city and the provision of urban services, as well as to strengthen competitiveness, and on the other hand, they satisfy the needs of present and future generations without negatively impacting the economic, social and environmental city components [UNCTAD, 2016].

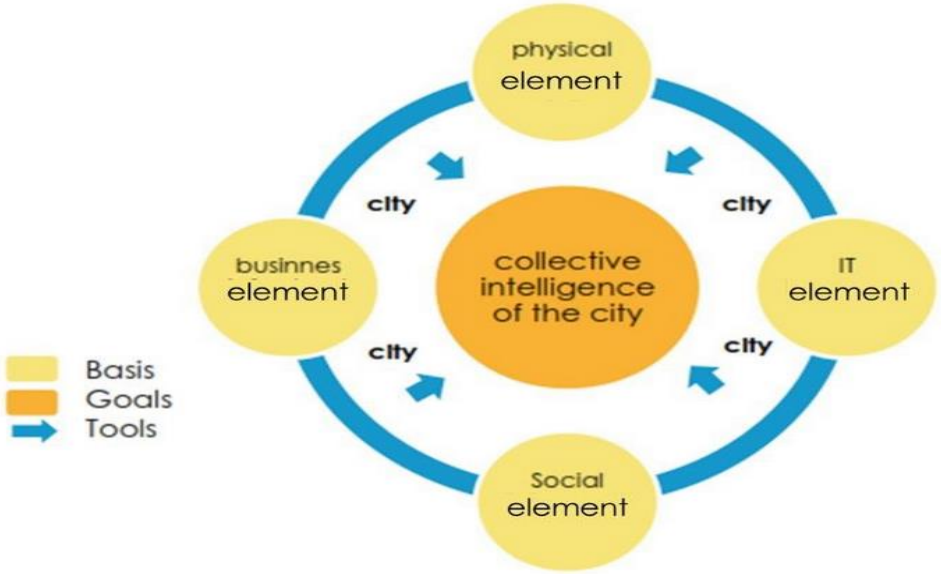


**Fig. 1. Smart City Definition Framework**

Source: [Fernandez-Anez, V., & Velazquez-Romera, 2015].

It should be noted that all existing concepts and definitions of a smart city emphasize various aspects of the functioning of the urban ecosystem, paying special attention to the development of information technologies, transport and telecommunications infrastructure, initiatives aimed at increasing economic and

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political efficiency and allowing the most efficient use of social potential. Thus, smart city systems provide collection, storage and processing of the received data, industry and cross-country analytics, allow predicting the development of situations and the behaviour of individual objects of physical infrastructure, technical systems and social conglomerations, as well as a global distributed multi-level system. Within the processes of smart city development, ICT is used to optimize urban processes, and this optimization is usually achieved by combining various elements and participants into an interactive intelligent system, the driver of which is the technology of the Internet of things (IoT). A big part of this ICT framework is an intelligent network of connected objects and machines, which supposes data transmission using wireless technology and the cloud.

Cloud-based IoT applications receive, analyse, and manage data in real-time to help local authorities, private entities and citizens make better decisions that improve quality of life.

Citizens engage within smart city ecosystems in various ways, by using smartphones and mobile devices and connected cars and homes. As a result, pairing devices and data with a city's physical infrastructure and services can cut costs and improve sustainability. At the same time, by means of IoT, communities can improve energy distribution, streamline trash collection, decrease traffic congestion, and improve air quality.

Despite the fact that there is no consensus on the identification of uniform criteria for the "intelligence" of a city, it is customary at the expert level to distinguish generations that differ in the purpose of using technologies, the level of development of physical infrastructure and technologies (including digital and data transmission), and the level of citizen involvement, as well as other stakeholders in urban development. Thus, world practice allows us to distinguish three conditional phases of development (generation) of smart cities (see figure 2):

SMART CITY 1.0 is characterized by technology providers encouraging the adoption of their solutions to cities that were really not equipped to properly understand the implications of the technology solutions or how they may impact citizen quality of life. The electrification and re-equipment of the physical infrastructure is taking place, isolated IT solutions are being introduced, and a semi-automatic infrastructure is being formed. The main stakeholders are companies that provide technology solutions and services.

SMART CITY 2.0 – in this generation, the local authorities have an acting role in helping determine what the future of their city is and what the role is for the

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deployment of smart technologies and other innovations. Thus, city administrators increasingly focus on technology solutions as enablers to solve problems in the fields of health, transportation, the environment and ecology, quality of life. The primary digital infrastructure of Smart City is being formed due to the introduction of Internet of Things technologies, 3G / 4G, broadband and mobile access to the Internet. The main role in the development of the city is assigned to the city authorities, while residents are involved in a limited way.

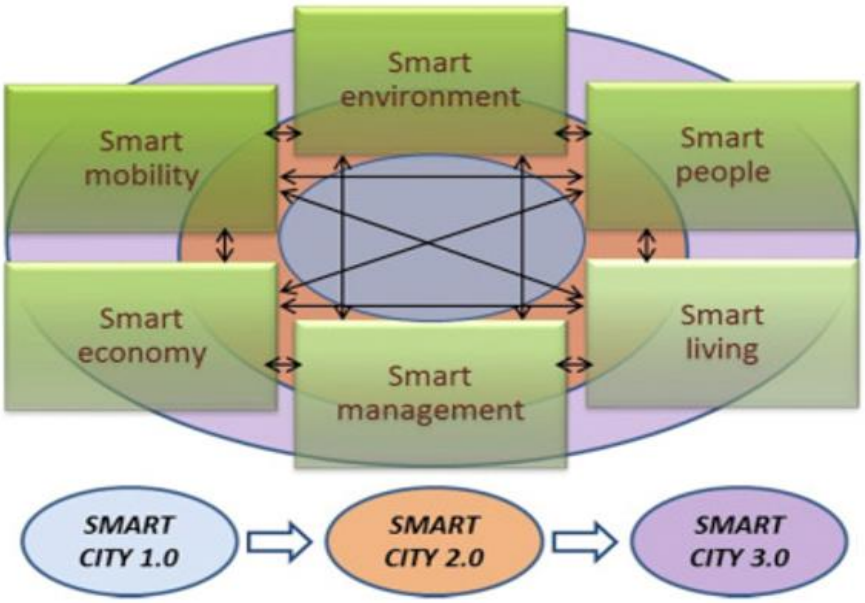


**Fig. 2. Smart city concept evolution**

Source: [Zawieska, J., Pieriegud, J., 2018].

SMART CITY 3.0 is a highly intelligent integrated city and appears to be grounded more in issues of equity and social inclusion. It is characterized by the combination of technologies that stimulate the development of social integration and entrepreneurship. The emergence of advanced digital services (digital transformation of sectors) and the formation of a fully integrated intelligent

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infrastructure that allows real-time collection and analytics of data, implement management of all processes in all areas of the infrastructure. There is a reorientation of urban processes in relation to data flows. This a unified ecosystem promotes citizen engagement, making them active participants in the development of the city.

From a technological point of view, a third-generation smart city is essentially a data-driven city (DDC) – the result of the digital revolution and intense digitalization of society, as well as the high spread of the Internet.

The key elements of the urban development of smart sustainable city system are:

*First, the city must be technologically equipped.* We are talking about instruments for fixing and collecting data - sensors, video surveillance cameras and similar devices that collect information about various processes (traffic, pedestrian movement, air quality, noise levels, etc.). This data, in turn, can be supplemented with information that is aggregated by other participants in the urban ecosystem (for example, mobile operators).

*Secondly, the principle of data openness must be implemented.* In general, open data is data generated and owned by public or private entities, provided on a non-competitive, license-free basis for commercial and non-commercial use. Free access to data should be provided not only at the level of interdepartmental municipal interaction - they should also be open for use by citizens and businesses. This approach contributes to greater transparency of processes, and hence a greater level of trust between individual participants in the urban ecosystem.

*Third, the data compatibility condition must be met.* Decisions on specific development issues often require the simultaneous recording and analysis of multiple data streams. In conditions when most of the collected data is presented in non-unified formats with different storage conditions and often requires manual processing, the issue of introducing standardized approaches, as well as tools for automating the collection, preparation and processing of data, becomes important. Overcoming this challenge depends on whether it is possible to develop and apply a single, "model" architecture for all components of the smart infrastructure that provides work with information. The challenge essentially boils down to the development of a conceptual model of a smart city that would provide the basis for the interaction of its various sectors.

Finally, another requirement for urban data is to provide *visualization interfaces and data access to their end users.*

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ISSN:2393-1795 ISSN-L:2068-6900

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**2. Sustainable digital transformation of cities within the transition ambition towards the circular economy.**

The fourth industrial (digital) revolution has the power to dramatically reduce the use of resources and pollution challenges. It is possible through making processes more efficient, as in case of big data analysis, or by simply replacing physical supply chains, as in the case of additive manufacturing. Digital technologies such as 5G, artificial intelligence and blockchain can accelerate and maximise the impacts of environmental measures. Transforming a municipality that has evolved organically for hundreds of years into a smart interconnected ecosystem represents a problematic challenge; at the same time, it demonstrates a significant opportunity for implementing circular economy and smart city solutions for the benefit of its citizens [Srivastav, P., Goldstein, N., 2019]. Thus, the smart city built on the principles of circular economy can unite technology, government, and people within an urban context. Thus, the circular economy concept can help transform cities into climate-smart hubs to save money, lower emissions, and improve living standards.

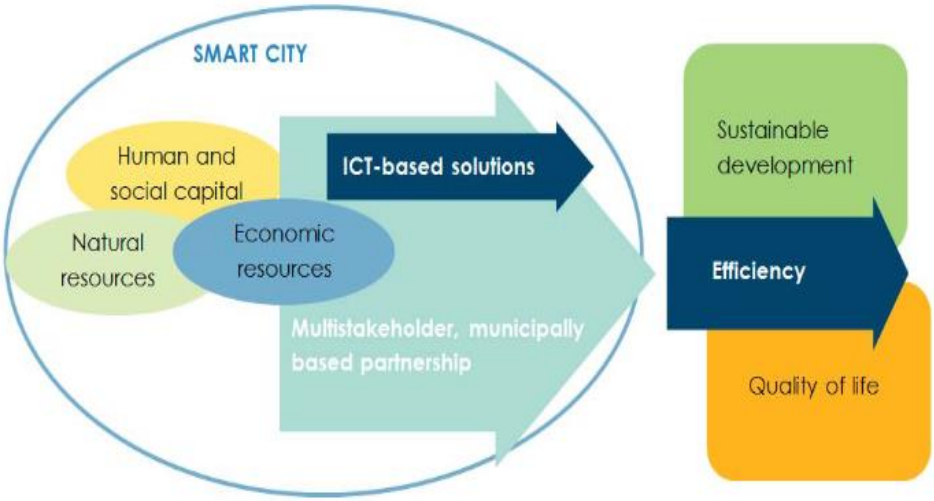


**Fig. 3. Goals of a smart city.**

Source: [ASCIMER, 2015]

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So, as a result of the above mentioned the goals of the Smart City notion can be summarized as shown in figure 3 [ASCIMER, 2015]:

- Achieve a sustainable development.
- Increase the quality of life of its citizens.
- Improve the efficiency of the city as a system

One of the goals of developing a Smart City is to achieve an urban sustainable development. Sustainable development is based on the interaction of three aspects that are interdependent and mutually reinforcing. These are the economic, social and environmental aspects of a development.

Thus, the circular economy concept can provide new, more impactful solutions to the smart city systems:

***New Mobility.*** Modern smart transport technologies in the city are focused on the active use of dynamic and multimodal information. Smart Mobility pursues to offer the most efficient, clean and equitable transport network for people, goods and data. From a technological point of view, the basic solutions for the emerging package are advanced GPS systems, connected and unmanned vehicles, video surveillance and license plate reading, dynamic simulation and traffic management, etc. These systems would mean fewer, better-utilized cars, with such positive side effects including less congestion, less land and investment committed to parking and roads, and the main effects of the introduction of the new technology package will be a decrease in road congestion, a decrease in the negative impact on the environment, as well as a reduction in the energy consumption of vehicles. Development of a smart city transport system, the emergence of new transport services and modes of transport, traffic control and management systems, various path calculation apps improve the traffic situation and increase mobility, as well as reduce the time to cover distances. Some cities use adaptive traffic control systems to optimize road traffic. In Barcelona, these solutions are introduced to reduce the time of arrival at the scene of emergency services by changing the system of traffic signals. According to PwC, such systems have already increased the speed of traffic during evening rush hours by 4%.

***Improving energy efficiency.*** Over the next five years, a package of new technologies in the field of smart energy will be formed. Basic solutions will be power electronics, as well as technologies in the field of energy storage, distributed energy, automatization of distributed networks and distributed intelligent control, generative design and modelling, etc. The transition to a new technological package will lead to significant changes in the electric power market of cities: in

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the new configuration, the end user of the power system is a prosumer - an active consumer who not only uses, but also generates energy himself. Energy exchange is monetized through a digital platform that allows you to design services and make micro investments without intermediaries. As a result, the Internet of energy is formed around the prosumer - an ecosystem of its producers and consumers, which seamlessly integrate into the common infrastructure and exchange energy. Smart cities and sustainable communities are already careening toward a low carbon future. A core part of that drive is locally derived power. Transition to the use of smart energy (smart distributed grids, smart control systems, etc.) and energy efficient technologies (smart lamps, smart lighting) will lead to savings in electricity consumption, a decrease in losses from interruptions in its supply, a decrease in accidents and capital costs for equipment, as well as to an increase in quality and reliability power grids. The drive toward low-carbon energy inadvertently boots circular economy approaches, putting more control in the hands of consumers. There is opportunity for utilities to take advantage of this trend by providing local power solutions, such as renewable power or resilient power backup. In San Francisco, as part of the Office Building Energy Efficiency Initiative, the Municipal Department of the Environment launched a project to conduct an annual benchmarking of energy consumption in non-residential buildings in the city and an energy audit every five years. As a result, the use of electricity was reduced by 7.9% in 176 office buildings.

***Smart environmental solutions.*** Reducing the negative impact on the environment is due to several factors: a more conscious attitude towards it and towards the measures to reduce negative impacts (for example, the Paris Agreement under the UN Framework Convention on Climate Change), a gradual increase in the share of renewable energy sources in the energy balance of cities, the introduction of energy efficient technologies, the introduction of smart waste sorting and recycling, traffic control systems and smart transport technologies. Smart city technologies are frequently cited as enabling buildings to develop fully closed water, nutrition, material, and energy loops. The package of technological solutions designed to provide better environmental protection for smart cities includes a whole set of components - these are systems for monitoring environmental parameters; and systems of control and monitoring of transport load, allowing to reduce the level of hydrocarbons; and solutions in the field of smart waste management (sensors for monitoring the level of garbage, solutions in the field of smart sorting and recycling of waste, smart connected garbage trucks); and

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smart wastewater treatment systems; and solutions in the field of renewable energy. For example, the launch of the SFpark Pilot Program in San Francisco, which forms prices for city parking depending on the level of demand at a particular time, led not only to a drop in the average cost of a parking space and to greater accessibility of parking spaces, but also a 30% reduction in greenhouse gas emissions. As part of the implementation of the smart city strategy in Vienna (Smart Wien Strategy), it is planned that by 2020 due to more efficient Waste management systems will be able to reduce harmful emissions into the atmosphere by 270,000 tonnes of CO2 equivalent. From the point of view of efficiency, such solutions contribute to improving the quality of the environment (air, soil, water), the transition to a more rational model of waste management and, as a consequence, improving the health of citizens and the sanitary situation in the city as a whole. A circular city would enable space to be highly utilized, thanks to shared and flexible office spaces and flexible, smart, and modular homes. There are also waste management applications. They work with a wireless ultrasonic sensor that measures the fullness of the bin, sends the data to a platform that analyses it, and then sends the information via a mobile phone application to the garbage truck driver. Thus, the garbage truck only collects the full bins, avoiding unnecessary itineraries on roads where the bins are not full. Therefore, this leads to immediate cost savings of up to 50% on fuel costs, while reducing carbon dioxide (CO2) emissions accordingly. Furthermore, cost saving is possible in buildings with the installation and operation of a system for monitoring of their energy consumption. In this way, a reduction of electricity consumption is achieved in real-time, but also of the energy footprint of carbon dioxide, something extremely important for the protection of the environment. Another very good example of circular cities / circular economy combination is the bike sharing philosophy. Citizens with the use of a dedicated application can find where co-sharing bikes are and use them in order to move around the city. Cycling promotes a healthy and sustainable lifestyle, and a bike share system encourages cycling by providing convenient access to everyone. To add on that, bike-sharing is one of the best examples of Circular Economy which also helps make cities become greener and transform cities market.

## Conclusion

The concept of smart cities has a great potential to address sustainability criteria by promoting citizen participation, developing innovative and smart solutions for

environment challenges, better life condition, increasing efficiency in city systems, and adopting a transparent and inclusive governance system.

A Smart City must be developed on the basis of a multistakeholder, municipally based partnership. These players can be businesses, local authorities' management, associations of various stakeholders. Depending on the main subject, the basic motive for the implementation of the concept of a smart city and the introduction of technology. This can be a target setting either to reduce costs and save, or to make a profit and expand sales markets.

**References**

[1] ASCIMER. (2015) Smart Cities Concept and Challenges. Available at https://institute.eib.org/wp-content/uploads/2017/02/2017_0131-ASCIMER-DELIVERABLE-1A-CONCEPT-CHALLENGES.pdf.
[2] Fernandez-Anez, V., Velazquez-Romera, G. (2015) Smart Cities: concept & challenges. Luxembourg.
[3] Ishida, T., Isbister K. (2000) Digital Cities: Technologies, experiences, and future perspectives, Lecture Notes in Computer Science, Year: 2005, Volume 3081, Page 233.
[4] Van der Meer, A., Van Winden, W. (2003) E-governance in Cities: A Comparison of Urban Information and Communication Technology Policies, Regional Studies, Vol. 37, No. 4, pp. 407-419.
[5] UNCTAD. (2016) Smart cities and infrastructure, United Nations Economic and Social Council 2016. Available at http://unctad.org/meetings/en/SessionalDocuments/ecn162016d2_en.pdf.
[6] Zawieska, J., Pieriegud, J. (2018) Smart city as a tool for sustainable mobility and transport decarbonisation. Transport Policy, Vol. 63/Apryl 2018, p. 39-50.
[7] Srivastav, P., Goldstein, N. (2019) Circular Economy: Shaping the Next Wave of Smart Communities. Available at https://www.fortnightly.com/fortnightly/2019/02-0/circular-economy-shaping-next-wave-smart-communities
[8] Sikora-Fernandez, D., Stawasz D. (2015) The Concept of Smart City In The Theory And Practice Of Urban Development Management, Romanian Journal of Regional Science. Available at http://www.rrsa.ro/rjrs/V1015.Sikora.pdf.
[9] Springer-Verlag, B., Komninos, N. (2015) The Age of Intelligent Cities. Smart environments and innovation-for-all strategies, Routledge, New York.