# CONCEPT SMART CITY IN MOSCOW AND IN BRATISLAVA

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***Abstract:***

*Sustainable development has represented a globally solved subject matter during the last few years, and smart cities are one of the areas supporting it. Smart Cities are currently considered as a very attractive approach towards the development of cities and city regions, their governance and planning. They are typical with application of modern information technologies to city governance and improvement of city life quality, and focused on more effective management aimed at supporting sustainable development of the city. The presented article introduces the Smart City concepts in Russia and in Slovakia, evaluating the Smart City level in Russian and Slovak capital cities through selected indexes. This article highlights problematic areas, and implemented and planned projects that could contribute to effective implementation of the Smart City Concept.*

***Keywords:***

*Smart cities, smart technologies, smart indexes, smart concept*.

***ACM Computing Classification System:***

*Applied computing - computers in other domains, human computer interaction.*

## Introduction

Rapid development of information technologies encourages the society to be progressing and respond to contemporary challenges. Cities play an important role in the economy, facing worsening city infrastructures, lack of budgetary sources, increasing pressure on environment, and increasing requirements of citizens and business sector on the city environment. The half of the whole population, i.e. 3.5 billion of people lives nowadays in the cities. Prognoses indicate that as much as 5 billion people will live in city areas till 2030 [1].

Implementation of the Smart City concept could resolve majority of the problems that modern cities currently face. We can speak today of transition to the third generation of the smart cities where the city development has been accompanied by complex digital transformation. In the intelligent digital city, its governance is based on data, i.e. „data – governed city", which is a key component of the city ecosystem and its parts – smart housing and communal services, smart energy, smart transport, smart healthcare, etc.

Sustainable development should be taken in account during the city governance system improvement. Sustainable development is a broad – spectrum subject matter aimed primarily at ensuring the future for the following generations. The document „*Transformation of Our World: Agenda 2030 for Sustainable Development*" also points it out, interconnecting three dimensions of sustainable development: the economic, the social, and the environmental dimension. It is an UN development program for period of years 2015 - 2030.

The program comprises total of 17 goals, amongst them also assurance of open approach, safety, resistance and environmental sustainability of cities and villages. Smart city represents one of the concepts of permanently sustainable development of principles and their application.

Caragliu et al. also state that smart city is close to permanently sustainable development [2]. They point out that city can be classified as a smart city when the investment in cybernetic infrastructure is aimed at supporting sustainable economic growth, life standard improvement, and effective management of natural resources.

Smart City is defined in the paper „Mapping Smart Cities in the EU" dated 2014, as a city „that makes efforts to solve its public issues most effectively through application of information – communication technologies"[3]. According to Fabianová, smart city is capable of providing all services to the citizens in the most effective way, and concurrently creates jobs, supports innovations, research, new ideas, respects the environment and considers the citizens´ opinions. It is a city that controls its mobility, energy consumption, buildings, city space and digital information in an energy efficient and sustainable manner in favor of its citizens, employees and tourists [4].

Main idea of the „smart city" is simple – the citizens should live a comfortable life, business activities should be effective and easy, and the public offices should successfully control it all. In fact, this approach has been materialized in the form of digital ecosystem that joins all components of infrastructure: from transport and social institutions up to the city properties. Such integration is feasible through the Internet of Things (IoT). This term should be interpreted as identification of things and monitoring of their movement in the Internet space. Along with open data, the Internet of Things has been frequently used in the smart city concepts [5][29].

The following components are of high importance for every smart city:

- Digital platform, being a „heart" of a smart city since it regulates all processes in the city infrastructure.
- Sensors and sensor systems ensuring data collection from the users and various city systems in the digital ecosystem of the smart city,
- Citizens and social institutions that are an integral part of the smart city.

Based on the above stated components, a smart city can control its data, energy, space and information in autonomous and most efficient way in order to improve the citizens´ life standard [6]. The term „smart city" is interpreted in various ways but all of them stipulate the essential role of information and communication technologies (ICT) that help to support current processes of city life in the most efficient way, engaging the citizens, enterprises and institutions. According to Slávik, ICT represents an important tool helping reach the economic and social goals of the smart city [5]. Definition by the European Committee dated 2018 also points it out, considering Smart City as a city using traditional networks and services more effectively thanks to implementation of digital and communication technologies, which positively impact upon the citizens and the business activities as such [7]. Giffinger specified 6 essential characteristics that should be developed in sake of as fast as possible progress in the fulfillment of the Smart Cities concept [8, 3]; see the following picture (Fig.1).

Projects that European and world cities implement in order to get closer to the Smart Cities concept include mostly those associated with transport and environment, for example sustainable commuting system, transport vehicles sharing, transport control, integrated multimodal public commuting system, innovative solutions in the area of lighting, heating, power engineering, and waste management [9].

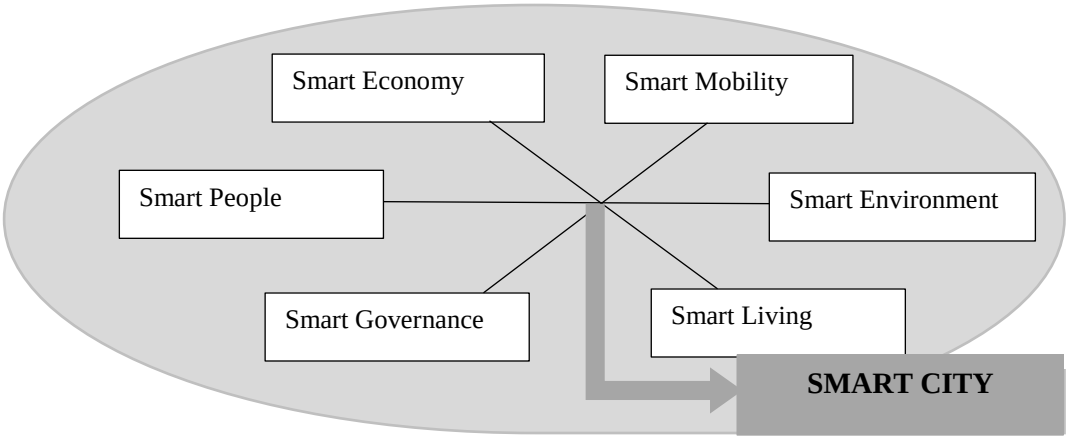



Fig.1. Dimension of Smart City.

## 1 Smart City in Russia

In case of development of smart cities, Russia has been highly subordinated to head economies and projects in progress they are mainly associated with digital and intellectual solutions of particular city services and infrastructures. Russia has generally not ranked on the top positions in the published international ratings of smart cities.

According to a few estimations, the volume of smart city technologies market should reach USD 2.4 billion till 2025. In fact, Russia is not a participant to these markets, which has been to large extent attributable to insufficient readiness of Russian cities for digital transformation. [10]

A few measures have been declared within the program „Digital Economy of the Russian Federation“, adopted by the Russian Government in 2017, which should influence the smart cities development [11].

In 2018, the Russian Ministry of Construction started preparing the Smart City program implementation plan, naming twenty cities that started with the program implementation. Following the global standards, Russian cities will have to acquire the systems of technology control, for example Internet of Things, where every part of the system, every object interacts with the other ones through the Internet.

In the spring 2019, the Russian Ministry of Construction along with the Central Development Center and Competence Center presented the „Smart City“ concept of technology implementation in the Russian cities. The concept was based on the analytic materials prepared by Center for Strategic Development „Northwest“ and published in the form of an expert-analytic report „Priority Paths of Smart City Technology Implementation in Russian Cities“ [12].

Main trends in the document are dedicated to technology solutions and institutional changes whose implementation should ensure development of a modern city governance system. Main principles of Smart City Concept implementation in Russia correspond to: human orientation, technology infrastructure, effective city governance, comfortable city environment, and economic feasibility of the solutions [13].

Requirement of transition to integrated intellectual solutions has been gradually presented in the Russian cities, and smart city concept implementation is perceived as an element of digital society and economy formation in Russia.

Selection of an optimum digital transformation scenario depends to large extent on the goals that the city set forth, and on the initial conditions of digital technology development.

Three models of digital transition can be distinguished for various types of Russian cities:

• decentralized model of digital transition – in Moscow, Petersburg, and in cities with more than 1 million citizens where digital transformation takes place upon participation of high amount of businesses, and in the conditions of significant market capacity for smart city technology implementation;

• centralized model of digital transition – suitable for big and medium size cities where the process of digital transformation is coordinated by the local self – government bodies, mobilizing all available sources and engaging high amount of process participants therein;

• local action model - suitable for big and medium size cities where certain problematic infrastructure sectors are subject to insufficient digital transformation sources.

A complex of the existing barriers will have to be overcome for purpose of successful implementation of any of the above models, including implementation of institutional changes related to the improvement of law regulation and the system of digital transition control on the level of local self- government, as well as mechanisms of coordination of transition to intelligent smart cities on federal level. Such processes could be started up through implementation of smart city pilot projects in special experimental zones. Independent polygons could exist for preparation of priority digital solutions, as well as the whole cities whose control functions allow for testing the concept on the entire site level (for example city Kronstadt) [10].

We have to admit that projects implemented in a Russian smart city are associated especially with digitalization and intellectual solutions for particular services and infrastructure elements.

In the area of transformation to „smart cities“, many Russian cities face problem in the form of insufficient regulation, not enough funds from the budget and necessary infrastructure. Using infrastructure developed as a part of the program Safe City, implemented in many Russian cities in the previous three years, can refer to one of the problem solutions.

„Smart“ potential of a city depends on whether or not there is a place for every citizen with his/her needs and ideas of city development. Involvement of citizens in the active work in this area represents the most important task of the competent authorities, namely in territorial development planning and public control over the implemented decisions. Attention is also paid to education. A new university profile should be opened under the name „Information Sources Management“ (specialization „State and City Government“) for purpose of successful modern city development. Such approach will prepare the experts with complex knowledge and skills, required for high professional smart city information system management. The graduates will be able to find a job in the city governance sector and to successfully communicate with citizens and enterprises, which should ensure permanently sustainable development of Russian smart cities.

Lack of data centers is another major problem of the smart cities, where all information from the city sensors is processed. Analysis of publishing activity indicates that own technology means are missed in Russia in most areas of smart city development [14]. Security problem of personal data and Internet of Things has been also highlighted, indicating not so optimistic future of the smart cities. With the aim to successfully resolve the issues of smart cities development in Russia, the country should be inspired by international experience in the Smart City system implementation in various world cities.

## 2 Smart City in Slovakia

According to the Slovak Ministry of Economy (guarantor for strategy of innovations creation and implementation including small and medium business support), the term Smart City has been perceived in Slovakia as an innovative approach to the development of cities and city regions, their governance and planning, applying technical and technology innovations including information

and communication technologies. It is an effort for increase of life standard and quality of business environment in cities and regions, increase of their operation effectiveness, aimed at increasing their safety, cleanliness, energy savings, and ability of their response to current and future social, ecological and other challenges and needs [9].

The Slovak Office of the Deputy Prime Minister for Investments and Informatics Solutions (UPVII) is a central coordination body that presented three necessary steps that Slovakia should made in order to support smart cities [15]:

1. Website platform containing all information related to the OP calls, information for self-governments, inspiring projects from Slovakia and abroad, contacts and reference to smart advisors, etc. on a single website.
2. The system of activities aimed at defining OPs (operating programs) that they will be funded from. OPs shall be included in the pilot scheme that offer solutions feasible for smart cities, namely OP Environment, OP Integrated Infrastructure, OP Effective Public Administration, and OP Integrated Regional Operating Program.
3. Publishing the calls for smart city concept support; provided that an advisory call center should be established for smaller cities.

At the end of January 2019, the Office of the Deputy Prime Minister for Investments and Informatics Solutions put into service the internet portal *www.smartcity.gov.sk*, where the applicants, cities and villages, and the whole public can find necessary information about the OP calls and the smart city topic. Support has been primarily directed to the area of power engineering, transport, environment, informatics solutions and waste management. The website contains summary of activity funding opportunities in the area of Smart Cities from the EU Structural and Investment Funds but also from other available sources [16].

Furthermore, the website contains contact numbers to established advisory – information centers in all regions, helping with reparation of European projects in the area of smart city free of charge [17].

The document „Support of Innovative Solutions in Slovak Cities" represents the basis of Smart City projects support in Slovakia. Self-government is a recipient of the innovative solution projects and enterprises with creative and innovative potential representing a driving force (Support of Innovative Solutions in Slovak Cities). Within the latest period, increasing interest in the Smart City concept has been reported from the Slovak self-governments´ environment, expressed through the implementation of various projects despite of the absence of Smart City system support. Implementation of the smart solutions offers the new opportunities of self-government control improvement, more effective cooperation between particular departments, as well as possibilities of better interconnection between self-governments and citizens including personnel provision for development of smart solutions and innovations, and their evaluation and implementation [18].

„Smart" governance is at the beginning of every good idea, exactly defining the areas of required improvement. As an example, it is commuting system in some cities, while in the other ones it is waste management or optimized use of the city energy. Often it is all together at once – cameras, traffic density, available parking lots, air quality, smart lights, and smart containers. All this can be monitored, data summarized in a single place, analyzed and optimized subsequently. Technologies developed currently also in Slovakia serve for this purpose [19].

The Smart City topic represents one of the priorities of Slovakia also during preparation of partner agreement for the new program period 2021 – 2027. Slovakia is interested in the increased utilization of recoverable funding forms in the new program period, and in further development of cooperation with the European Investment Bank that the Memorandum of Cooperation was signed with. The Memorandum will help us effectively spend the EU Structural and Investment Funds during the new program period for sustainable development of cities and regions, based on low-carbon economy [20].

## 3 Analysis of Smart City Evaluation in Moscow and in Bratislava

Fulfillment of the Smart City concept can be evaluated through various indexes. We chose three of them to compare the Russian and the Slovak capital city:

1. IMD Smart City Index (IMD SCI) that is a result of the analysis made by the Smart City Observatory of the Global Competitive Center in cooperation with the Singapore University of Technology and Design.
2. IESE Cities in Motion (CIMI) is a research platform launched jointly by the Center for Globalization and Strategy and IESE Business School's Department of Strategy.
3. Index of Smart Cities developed by the company Easy Park (SCI EP).

The results are presented in the following tables prepared according to evaluation of the above stated companies.

Table 1. Rating of analyzed places according to selected indices.

| Country | Capital City | Rating | | |
|---|---|---|---|---|
| | | IMD SCI 2019 | CIMI 2019 | SCI EP 2019 |
| Russia | Moscow | **72** | 86 | 97 |
| Slovakia | Bratislava | 84 | **70** | **83** |
| Number of Cities Compared | | from 102 Cities | from 100 Cities | from 174 Cities |

The results in (Tab.1) indicate that Bratislava ranked on better positions than Moscow within evaluation of CIMI and SCI EP index. On the contrary, Moscow ranked higher than Bratislava in case of IMD SCI index application. In the following section we focused on more detail picture of the areas of evaluation, namely which one of them are more dominant in which city in case of particular indexes.

Index IMD SCI is an index pointing out the Smart City perception through the citizens´ opinions set off by economic and technology aspects. (IMD Smart City Index) [21]. It evaluates five key areas (health and security, mobility, activities, opportunities and the public matters administration) in two fundamental pillars (Tab.2). The first pillar is a structure referring to the existing city infrastructure, and the second pillar represents the technologies, namely technological provision and services available to the citizens [22].

Table 2. Comparison IMD SCI in Moscow and in Bratislava

| Evaluation area | Structures | | Technologies | |
|---|---|---|---|---|
| | Moscow | Bratislava | Moscow | Bratislava |
| Health, Safety | 48,934 | **49,536** | **63,773** | 48,63 |
| Mobility | **42,76** | 27,525 | **60,04** | 46,345 |
| Activities | **74,725** | 53,345 | **83,47** | 74,45 |
| Opportunities (Work, School) | 59,236 | **63,88** | **69,123** | 56,013 |
| Governance | **46,96** | 44,195 | **58,605** | 43,647 |

Presented data indicate that Moscow dominates over Bratislava especially in evaluation of the second pillar. Bratislava is more dominant in case of the first pillar in the area of health, security and the opportunities. The biggest difference between the two cities was reported in the area of activities and mobility.

IMD Smart City Index is considered the first global index evaluating the city „Smart" level, evaluating the city municipalities also according to citizens´ perception and indicated in the conducted opinion poll.

From a list of 15 indicators, survey respondents were asked to select 5 that they perceived as the most urgent for their city. The higher the percentage of responses per area, the greater the priority for the city (Fig.2).

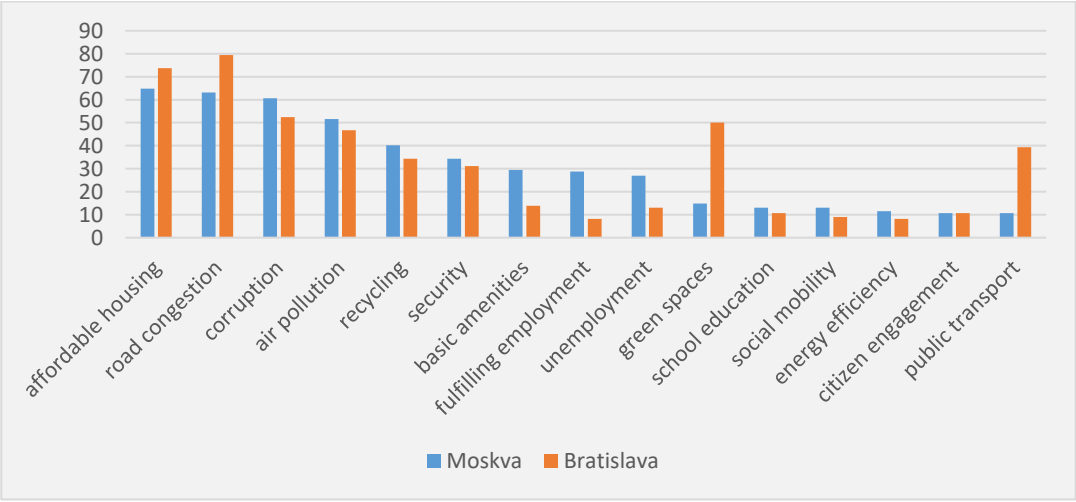



Fig.2. % of respondents who chose the Priority Area: Moscow and Bratislava.

The stated opinion poll indicates that the first three areas are considered most urgent by the citizens of both Moscow and Bratislava. Different opinions were reported on the 4th place where air pollution dominates in Moscow while in Bratislava they are green areas. The analyzed cities didn´t show major difference on the fifth place. Comparison showed significant difference in the public commuting system that ranked on the 6th place in Bratislava and on the last position in Moscow in the terms of urgency. This result is associated with the fact that Moscow ranked much higher in the area of mobility.

Index CIMI evaluates (Tab.3) the development level of nine key areas (economy, human capital, social cohesion, environment, public governance, city planning, international influence, technologies, and mobility and transport). Maximum reached Score CIMI refers to 200 points, the higher is the value, the better is ranking. Along with the ranking score, the next table shows the order of analyzed cities in particular areas of evaluation. [23]

Table 3. Comparison CIMI in Moscow and in Bratislava.

| Evaluation area | Moskva | | Bratislava | |
|---|---|---|---|---|
| | Ranking | Score CIMI | Ranking | Score CIMI |
| Mobility and Transportation | **65** | 55,91 | 85 | 59,92 |
| Technology | **92** | | 113 | |
| International on treach | **73** | | 122 | |
| Urban Planning | **22** | | 67 | |
| Governance | **43** | | 50 | |
| Environment | 136 | | **35** | |
| Social Cohesion | 163 | | **14** | |
| Human Capital | **7** | | 49 | |
| Economy | 100 | | **91** | |

Based on the data, we can state that Bratislava reached score 59,92 and ranked higher than Moscow. Our capital city was better evaluated especially in the area of social cohesion and environment. Moscow ranked much worse in these areas. We should state that Moscow was evaluated very high in the area of human capital which is mainly associated with education.

Index SCI developed by EP considers seven basic criterions that summarize the data of other indicators in the area of transport and mobility (car sharing services, traffic, public transport, e-charge spots and infrastructure investments), sustainability (clean energy, smart building, waste disposal, environmental protection, environmental performance), governance (citizen participation, digitalization of government, urban planning, and education), innovation economy (business ecosystem, blockchain ecosystem), digitalization (4G LTE, Internet speed, Wifi hotspots, smartphone penetration, cyber security), and living standard and expert perception. Each factor is evaluated by score within 1 – 10; the higher is the score, the better is evaluation. (Tab.4) contains calculation of the average score in particular areas of evaluation. [24]

Table 4. Comparison Rank Score in Moscow and in Bratislava according SCI EP.

| Evaluation area | Moskva | | Bratislava | |
|---|---|---|---|---|
| Transport and Mobility: | 5,015 | | 4,335 | |
| - smart parking | 2,78 | | 5,13 | |
| - **car sharing services** | **9,47** | | 3,04 | |
| - traffic | 1,45 | | 7,58 | |
| - public transport | 1,08 | | 3,87 | |
| - **e-charge spots** | **9,09** | | 4,33 | |
| - infrastructure investments | 6,22 | | 2,06 | |
| Sustainability: | 2,772 | | 3,97 | |
| - clean energy | 4,15 | | 4,31 | |
| - smart building | 4,03 | | 1,91 | |
| - waste disposal | 2,07 | | 2,3 | |
| - **environmental protection** | 1,08 | | **7,81** | |
| - environmental performance | 2,53 | rank/score | 3,52 | rank/score |
| Governance: | 4,6875 | 4,29 | 5,75 | 5 |
| - citizen participation | 1,54 | | 2,86 | |
| - digitalization of government | 9,39 | | 5,92 | |
| - urban planning | 6,29 | | 7,20 | |
| - education | 1,53 | | 7,05 | |
| Innovation Economy: | 5,03 | | 6,74 | |
| - business ecosystem | 1 | | 6,45 | |
| - blockchain ecosystem | 9,06 | | 7,03 | |
| Digitalization: | 4,134 | | 4,876 | |
| - 4G LTE | 1,68 | | 6,75 | |
| - Internet speed | 2,29 | | 7,58 | |
| - **Wifi hotspots** | **10** | | 5,69 | |
| - smartphone penetration | 2,6 | | 1,92 | |
| - cyber security | 4,1 | | 2,44 | |
| Living Standard | 1,68 | | 2,74 | |
| **Expert Perception** | **6,64** | | **9,16** | |

The table indicates that Bratislava reached better evaluation score. The best results were achieved in the evaluation of Expert Perception (Moscow score 6,64 and Bratislava score 9,16). Of the partial indicators, Bratislava reached the highest value in Sustainability in the indicator of environmental protection (score 7,81). Moscow reported major deviations in particular values. The best results was reached in transport and mobility in the indicators - car sharing services (score 9,47) and e-charge spots (score 9,09). The best rated indicator is wifi hotspots (max. score 10) in digitization.

## 4 Discussion

The presented evaluation results don´t show major differences in the ranking of compared cities within the global Smart City ranking. The order of the cities mostly depends on the type of evaluation index and the indicators that are taken in account in determination of Smart City level in particular index. This is why the results differ from one another in the comparison when various indexes are used. Major success of Moscow refers to evaluation according to index CIMI where the city ranked on the 7$^{th}$ position in the global ranking in the area of human capital, mostly associated with education quality. Moscow ranked behind London, Los Angeles, New York, Boston, Berlin and Paris. Accordingly, people, their education and increase of digital literacy are considered one of the most important factors of Smart City development in Russia.

Comparing Bratislava and Moscow, we can state that Moscow ranked better in the area mobility in all evaluations. Moscow reached more positive results also in the area of technologies and governance. On the other hand, Bratislava dominates in the area of environment and social cohesion.

Both cities developed the Smart City development concept that has been continuously improved. In Bratislava, it is the concept called Reasonable Bratislava 2030. This concept represents an open intention of the whole city development, aimed at contributing to the life standard improvement. In the document, our capital city decided to seek reasonable solutions in 12 areas, namely in the city governance, mobility, power engineering, environment, circulation economy, undertaking, public space, education, social inclusion, culture, tourism, and sport. The area of environment (79.2 %) and mobility (71.8 %) are considered of key importance according to conducted opinion poll. [25].

Within the support of these areas, Bratislava has implemented a few projects, for example Up! City, Bike sharing, Pilot Project of Semi-Underground Containers, Pilot Project of Public Commuting System Preference, Electronic Solution of Bratislava Self-government Services, Contact Point of Services for Citizens, Bratislava City Card, etc. [26].

In the capital of Russia, work continues on the digital strategy of Moscow, Smart City - 2030. It is proposed to use two indexes as important indicators of the strategy: quality of life and quality of the urban environment.

In general, “Smart City - 2030” is a high-level strategic document that is being developed by the Moscow Department of Information Technologies with the involvement of experts, the business community and citizens. The document defines the goals, objectives and directions of further development of Moscow as an innovative smart city of the future [27].

A unique ecosystem is being created in Moscow - a set of digital services, services and capabilities, platforms for business interaction with the city, consumers and partners, the key element of which is a personal account on the official portal of the mayor mos.ru. With its help, entrepreneurs can receive 90 public services, more than half of them exclusively in electronic form.

Today, the key task of the municipalities of the Russian Federation is the creation of a single IT platform, which should become the basis for the development of smart cities.

The introduction of modern technology requires a major infrastructure upgrade. One of the key projects is the creation of a 3D map of Moscow. In the future, this technology can be used to build routes for unmanned vehicles or aircraft.

For urban planning and city management, it is almost indispensable. For example, it is possible to select a specific point on the map and get all the information about this territory: about accomplishment, urban development, underground utilities, documentation. This function helps the city government to quickly make management decisions and monitor the execution of orders. In the future, all projects implemented in Moscow will initially be "embedded" in a 3D city, where they will evaluate their impact on citizens. It will be possible to calculate the load of the building on the existing infrastructure of the city and, for example, evaluate how much it fits into the architecture of the quarter. [28].

## Conclusion

Innovations and information-communication technologies represent the basis of Smart city. Using the advanced technologies, e.g. „Internet of Things", „Big Data", „Machine Learning" improves the city governance and social-economic city indicators, and increases quality of provided services and quality of the environment. The city is progressing and becomes more attractive for its citizens and visitors. The Smart City concept becomes a fundamental strategic document of cities, implemented in gradual steps.

Active attitude of the cities to the development of smart city concept represents the basis of success and progress in the global rating systems. Many companies, research and education institutions develop and continuously improve the Smart City indexes that determine the position of particular cities, highlighting the quality of their key areas. Results of these ratings map the situation and refer to a good starting point of the system improvement. In this way, the cities can become more comfortable, secure and open to useful innovations in the future; capable to better ensure their competitiveness and sustainability.

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