Theoretical and Empirical Researches in Urban Management
Volume 12 Issue 4 / November 2017

COMPREHENSIVE ASSESSMENT OF ROAD AND COMMUNAL INFRASTRUCTURE AS AN IMPORTANT TOOL FOR SUSTAINABLE DEVELOPMENT OF THE URBAN ECONOMY

Elena Ivanovna DANILINA
Moscow Technological University (MIREA)
20, Stromynka, Moscow, 107996, Russia

Vladimir Evgenevich CHEBOTAREV
Russian University of Transport (MIIT),
127994, Moscow, Obraztsova Str., 9, Bld. 9, Russia,

Abstract
The article provides methodological approaches to a comprehensive assessment of the state of the road and communal infrastructure as the main components of the urban environment. Outcomes of the study indicate a low level of technical state of communal facilities of the Central Federal District (CFD) administrative centers. The conducted study allows distinguishing three groups of administrative centers with different levels of infrastructure development. The author comes to the conclusion that the development of targeted programs at the level of municipalities is required in order to guarantee timely financing of measures for the development and modernization of engineering systems of the housing and utility infrastructure. A public-private partnership can become one of the efficient mechanisms for raising investment in the projects of modernization of the road and communal infrastructure of the urban economy. Raising private investment at the level of municipalities requires extending guarantees for investors in public-private partnership (PPP) projects, including those in the fulfillment of obligations of public-law entities, as well as developing special mechanisms at the state level for subsidizing municipal entities for the implementation of PPP projects.
Keywords: road network, communal facilities, urban infrastructure, urban economy, infrastructure development, public-private partnership.

1. INTRODUCTION

Since the majority of the world's population lives in cities, while urbanization and urban life become dominant phenomena throughout the world, the problems associated with sustainable development of the urban economy have come to the fore in international discussions (European Union, 2011).

Cities and megacities as centers of innovations and knowledge economy are the drivers of economic growth and play a key role in the territorial development of Russia (European Communities, 2009). Cities can be regarded as the source and solution for many of today's economic, social and environmental problems.

On the one hand, they are drivers of the economy, providing a concentration of resources for creating material wealth and attracting a large number of people. Cities are a fertile soil for the development of science and technology, innovation, culture, as well as opportunities for personal and professional development of human resources.

On the other hand, they face a range of social and environmental problems, such as provision of affordable housing for the population, battle with poverty, unemployment and crime, environmental pollution. High population density, concentration of industrial production and improper infrastructure development limit the ability of natural processes to counteract the environmental consequences of human activity (Radulescu and Dociu, 2014).

Cities are constantly changing and developing faster than ever, and the task of managing these changes is extremely challenging. Unprecedented rates of urbanization and population growth are observed in many cities, while others experience a decline in population.

Nevertheless, a number of common problems for all cities can be identified (PricewaterhouseCoopers, n. d.):

- increase in life expectancy leads to an increase in the need for healthcare;
- climate change leads to extreme and often catastrophic weather events; and
- industrialization leads to large-scale pollution of the environment.

Having faced with multiple problems, the city authorities must manage changes and control them in order to provide the population with a living standard that meets the modern expectations of society.

Favorable urban environment is the most important aspect of competitiveness of the cities, the base, source and goal of urban development directly related to the public interest, to the quality of life of the population and to the sustainable development of the urban society and the economy (Li, et al., 2013).

Establishment of the urban environment includes the formation and management of utilities, municipal facilities, social medium and urban order.

The urban infrastructure management requires not just a better coordination and a command work mechanism, as well as the need to create a full set of scientific methods of analysis and forecasting, in order to conduct a real-time dynamic monitoring of the state of urban facilities and assess the infrastructure of the city in a timely and accurate manner (Kuznetsova 2014; Danilina, Mingaleva and Malikova, 2016; Danilina et all., 2016).

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Regardless of the impact of changes on the state of the urban environment, one thing will remain unchanged – provision of the necessary infrastructure and the most efficient provision of municipal services.

Ensuring an efficient, productive and sustainable urban infrastructure is very important for the provision of the city's main road from which economic success and prosperity can grow – a critical infrastructure such as:

- Mobile and efficient transport infrastructure with sufficient capacity to meet increasing needs;
- Stable and reliable energy infrastructure that provides the capacity to meet the most urgent needs;
- Clean and abundant water supply;
- Efficient sewage treatment infrastructure, which meets modern sanitary and hygienic standards;
- Safe and secure environment where people can confidently live and work.

At the same time, the developed cities need modernization of infrastructure facilities due to their malfunction or a high level of obsolescence. Young cities strive to create a modern infrastructure and urban systems that would enable them to move to a higher level and position themselves as global leaders and megacities of the new generation.

Investing in infrastructure facilities creates new jobs, reduces production and transport costs of enterprises and develops social services. The cumulative result of infrastructure investment is a sustained economic growth and improvement of the population’s living standards.

The goal of this article is to identify the areas of improvement of infrastructure in the context of sustainable development of the urban economy in the regional administrative centers of the CFD of the Russian Federation.

A number of tasks are being solved within the framework of this paper to achieve this goal:

- Present a methodology for analyzing the infrastructure development of the city;
- Conduct a comparative analysis of urban infrastructure development across the regional centers of the CFD;
- Develop proposals for the formation of a strategy for infrastructure development of the CFD cities

2. LITERATURE REVIEW

Most of the world's population resides in cities that are centers of economic growth and labor productivity but can lead to social inequality or irreversible damage to the environment if they develop in the wrong direction (Alonso, Monzón and Cascajo 2015).

Sustainable development of cities as a complex, rapidly changing and highly integrated system requires the expansion of the scope of inter- and interdisciplinary approaches that go beyond the traditional socio-ecological and socio-technical approaches to the study of the social and environmental infrastructure in cities (McPhearson et all, 2016).

Multiple studies reveal that sustainable development of the urban economy – in particular, its opportunities and risks, varies depending on the changes in the economic, environmental and human capital (Amekudzi, Khayesi and Khisty 2015).

A review of literature sources reveals that simultaneous balanced development in the economic, social and environmental areas is required to achieve sustainable development (Boyeret all, 2016).

Papers of many researchers are devoted to the environmental aspects of sustainable urban development.

Gao and Christensen presented the criteria for strategic environmental assessment, which contain information useful in decision-making and can be used in the process of goal-setting for the development of the urban economy (Gao, Christensen and Kørnøv 2017).

Addanki and Venkataraman note that intensification of urbanization leads to the increasing pollution and limited resources of the urban economy (Addanki and Venkataraman 2017). They presented proposals for development plans in the context of sustainable urban transformation and climate change in their paper.

The works of Abed and Woodcraft (2015), Peterson (2016), Boström (2012) and Murphy (2012) are devoted to the problems of securing the social sustainability of the urban economy. Although the social dimension of sustainable development has been widely recognized, no clear indicators of its assessment have been defined and agreed upon by Dempsey, Bramley, Power and Brown 2011).

Abed notes that sustainable development is quite a widely-used term. However, environmental and economic aspects dominate in most studies. Social aspects are researched to a lesser extent. In his study, Abed, A. R. proves the need to consider the role of social infrastructure in scheduling and planning of the urban development (Abed 2017).

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Studies reveal that various scopes of cities face many problems in the process of sustainable development and require implementation of certain measures. From the standpoint of economic development, it is necessary to regulate the structure of the economy and industry and contribute to the development of green and low-carbon production. From the standpoint of social progress, the state should improve the system of social management and the guarantee of rationality and justice, education and healthcare when allocating resources. Talking about the environmental protection, it is necessary to promote the modernization of environmental technology, reduce energy consumption and increase investment in pollution control. (Sun et all, 2016).

Methodological aspects of the assessment of sustainable development of urban systems are reviewed in the works of Jain and Tiwari., Buzási and Csete., Spiller (Spiller, 2017), Turvey (Turvey, 2017), and others.

Buzási and Csete highlight that despite the lack of a comprehensive and widely accepted concept of "urban sustainability", the methodological aspects of assessing the sustainable urban development remain one of the most relevant research topics in various academic fields (Buzási and Csete 2015).

Scientific-methodological approaches to assessing and forecasting the sustainable development of cities and urban agglomerations were developed in the papers of Fang and Yu. (2017), Zinatizadeh (2017), and others.

Singh et all. (2012) note that sustainability indicators and calculation of the composite index of sustainability of particular territories take on great importance and can be used as a powerful tool to develop policy in such fields as the environment, economic, social or technological development of the city.

Sustainability of indicators and the composite index takes on great importance and is increasingly recognized as a powerful tool to develop policy and public communications in providing information about countries and corporate performance in such fields as the environment, economic, social or technological improvement.

Phillis., Kouikoglou. and Verdugo modified the model of assessing the country sustainability in order to assess sustainability of cities around the world (Phillis, Kouikoglou and Verdugo 2017). According to the provided method, general sustainability of cities is reviewed as a function of two main inputs: the ecology and prosperity of the urban environment.

Egilmez., Gumus and Kucukvar have developed an original approach to assessing the environmental sustainability of cities on the basis of the method of hierarchical fuzzy decision-making (Egilmez, Gumus and Kucukvar 2015). Application of this method in a comparative assessment of the US and Canadian cities allowed to conclude that CO2 emissions from public transport had the most significant impact on the environmental sustainability of cities.

The model of environmental development of urbanized territories developed by Russian academics from the Saratov State Academy of Law (Abanina et all, 2017) is of some interest in the assessment of sustainable urban development. The model contains four levels of factors, including natural resources of the territory, its social characteristics, economic growth, and impact on humanity.

The approach to assessing the sustainability of urban development, proposed by Italian academics (Devitofrancesco et all., 2016), is of some interest. The new system of indicators is divided into three topical fields: (I) environment; (II) urban infrastructure; (III) economy and society, and (IV) institutions and enterprises.

Review of scientific publications on the problem under study revealed an increasing interest in developing the concepts of "smart" sustainable cities. In order to identify problems and find their solutions, scientists from the Norwegian University of Science and Technology conducted a detailed review of the existing works in this field and proposed an integrated approach to building a smart model for sustainable urban development (Bibri and Krogstie 2017).

Jain D. and Tiwari G. proposed a systemic approach to the selection of sustainable mobility indicators for cities (Jain and Tiwari 2017). A method they developed includes both subjective judgments to assess indicators based on a set of criteria and objective estimates of causal chains and network structures. However, the authors noted the need for further work on the development of measurable indicators associated with the access of the population to housing and public utilities and street lighting, because they were not discussed in detail in the existing literature.

A special role in implementing the strategy of sustainable urban development is assigned to the urban infrastructure (Judyta 2016). Special attention of researchers has recently been attracted to the issues of increasing the building sustainability and shaping of "green infrastructure." The methodological issues of assessing the cost effectiveness, project management and tools for assessing the sustainable development of territories also remain relevant (Thomé et all., 2016).

The problems of uneven infrastructural development of individual regions are noted in the joint works of Rana, Bhatti and Arshad (2017). The issues of shaping the urban environmental infrastructure are considered.

Derrible S. claims that cities will have to solve many problems in the 21st century, and the most important role in their solution is assigned to planning the urban infrastructure systems (Derrible, 2017). A number of researchers claim that improving the sustainability of the urban economy is impossible without the

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implementation of a strategy to minimize accidents and unexpected disruptions at the urban infrastructure facilities (Mugume et all, 2017).

3. METHODS

A review of the outcomes of the relevant empirical studies reveals that a significant number of relevant indicators can be used for assessment of the infrastructure development of the urban economy.

The used research methods are represented in two groups. The first includes methods for assessing the objective indicators of urban infrastructure published on official websites and in databases of territorial statistical offices. The objective indicators include actual data that do not depend on personal assessments. The objective indicators are divided into two units: road and communal infrastructure.

To assess the development of infrastructure facilities, several indicators were selected within each unit, which are presented in Table 1.

TABLE 1 - INDICATORS OF THE STATE OF THE INFRASTRUCTURE DEVELOPMENT OF THE URBAN ECONOMY

Indicator	Calculation
Transport infrastructure	
Density of the road network km/thous. sq.km. of the territory (X1)	Length of public roads/area of the city territory
Provision of public roads with gas stations, units per 1,000 km (X2)	Number of gas stations/length of public roads
Proportion of hard-top roads in the public road network, % (X3)	Length of hard-top roads/total length of public roads
Proportion of roads with improved surface in the public road network, % (X4)	Length of roads with improved surface/total length of public roads
Communal infrastructure	
Level of illumination of streets, driveways, embankments, % (Y1)	Length of illuminated parts of streets/total length of streets, driveways, embankments
Level of technical serviceability of gas networks, % (Y2)	Length of the street gas network in need of replacement and repair/total length of the street gas network
Level of upgrade of gas networks, % (Y3)	Street gas network replaced and repaired in the reporting year/total length of the street gas network
Level of technical serviceability of heat and steam networks, % (Y4)	Length of two-pipe heat and steam networks in need of replacement/Length of heat and steam networks
Level of upgrade of heat and steam networks, % (Y5)	Heat and steam networks replaced/Length of heat and steam networks
Level of technical serviceability of water supply networks, % (Y6)	Length of two-pipe water supply networks in need of replacement/Length of water supply networks
Level of upgrade of water supply networks, % (Y7)	Water supply networks replaced/Length of water supply networks
Level of technical serviceability of sewage networks (Y8)	Length of two-pipe sewage networks in need of replacement/Length of sewage networks
Level of upgrade of sewage networks (Y9)	Sewage networks replaced/Length of sewage networks

The second group includes methods for assessing subjective indicators, which represent a measurement of individual perceptions and an assessment of the population's satisfaction with the city's infrastructure development. The indicator of population's satisfaction is a key criterion for the quality of the urban environment. The degree of the population's satisfaction with the results of the activity of local authorities in the area of their activity is defined through pollinThe study uses a weighted method of calculation of the comprehensive index of development of urban infrastructure, calculated as a mean value of the general indices of each of the units describing the development of urban infrastructure.

General index of each of the units describing the development of urban infrastructure is a sum of the partial indices adjusted for the weighting factor. The weight of each unit is based on the principle of their equivalence.

I_{ui} = a$a * I_{ri} + b * I_{ui}$

where I_{ui} is the index of development of engineering urban infrastructure,

I_{ri} is the index of development of road urban infrastructure,

I_{ui} is the index of development of communal infrastructure.

$$I_{ri} = \frac{\sum X_{in}}{n}$$

where X_{in} is the city's normalized indicator by the selected criterion,

N is the number of estimation criteria.

Since the units of measurement in the system of assessing the city infrastructure development are different, it is necessary to perform preliminary processing of statistical data for their comparability, i.e. the normalized indicator is calculated using the following formula:

X_{n1}= (X-X_{min})/(X_{max} – X_{min})

X in this formula means the actual indicator of the city i,

X_{min} and X_{max} are the minimum and maximum values of the selected indicator in the group of cities under study.

The normalized indicator for indicators whose growth describes deterioration in infrastructure development is calculated as 1-X_n.

4. RESULTS OF THE ASSESSMENT OF DEVELOPMENT OF ROAD INFRASTRUCTURE

The CFD) is the largest macroeconomic region in the Russian Federation with a total area of 650.2 thous. sq.km, which is home to 39,091.2 thous. people, of which 82% is the urban population.

The district includes 16 administrative centers of regional significance. Ivanovo, Kostroma, Kursk and Tula were excluded from consideration due to the lack of open statistical data describing the development of infrastructure; 11 cities participated in the study.

The study shows significant differences between the administrative centers of the CFD both in terms of the area and the population. For example, the gap in the area exceeds 6-fold, in the population – 3.5-fold.

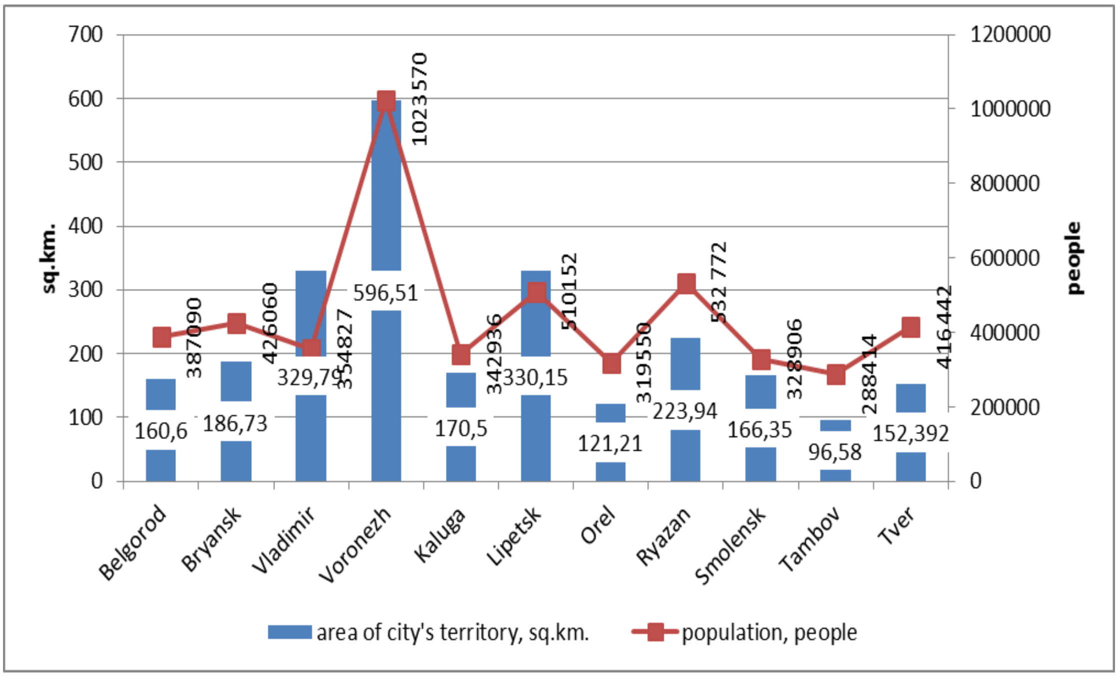

FIGURE 1 - AREA AND POPULATION OF THE ADMINISTRATIVE CENTERS OF THE CFD (AT YEAR-END 2015)

Voronezh is the largest from the administrative centers of the CFD in terms of population and area, Tambov has the smallest population and area.

A properly organized, extensive road network is the most important part of the urban infrastructure that ensures safe traffic conditions for vehicles and pedestrians. The statistical indicators describing the development of the road infrastructure of the administrative centers of the CFD are shown in Table 2.

TABLE 2 - INDICATORS OF THE DEVELOPMENT OF THE ROAD INFRASTRUCTURE IN THE CITIES OF THE CFD (ACCORDING TO 2015 DATA)

	Belgorod	Bryansk	Vladimir	Voronezh	Kaluga	Lipetsk	Orel	Ryazan	Smolensk	Tambov	Tver
Number of gas stations, ea.	63	55	37	13	39	61	11	49	44	42	59
Length of public roads, km.	609.2	818	375	1,526.5	391	540	457	466	383	338	580
Length of hard-top roads, km	609.2	525	371	1,001	333	431	457	404	340	321	487
Length of roads with improved surface, km	609	492	370	1,001	333	431	301	404	270	321	388
Density of the road network km/sq.km. of the territory	3.79	4.38	1.14	2.56	2.29	1.64	3.77	2.08	2.3	3.49	3.81
Provision with gas stations, units per 100 km of roads	10.3	6.7	9.9	0.9	10	11.3	2.4	10.5	11.5	12.4	10.2
Proportion of hard-top roads in the public road network	1	0.64	0.99	0.66	0.85	0.8	1	0.87	0.89	0.95	0.84
Proportion of roads with improved surface	1	0.6	0.99	0.66	0.85	0.8	0.66	0.87	0.7	0.95	0.67
Degree of population's satisfaction with the road quality, %	73.15	37.8	54.7 5	34.9	69	32.6	25.9	29	29	24.6	28

The total length of public roads in cities under study is 6,482.3 km. The leading cities by the length of public roads are Voronezh (1,526.5 km), Bryansk (818 km) and Belgorod (609.2 km). The road network density is one of the key indicators of the development of transport infrastructure, which shows the provision of the city's territory with roads. The poor provision with roads is noted in Vladimir (1.14 km/sq.km), Lipetsk (1.64 km/sq.km) and Ryazan (2.08 km/sq.km). At the same time, it should be noted that the indicator of the road density in the administrative centers of the CFD exceeds the average Russian indicator. In general, provision of roads with gas stations in cities is within the standard range, according to which the maximum distance between gas stations should not exceed 100 km. The exception is Voronezh, where this indicator is below 1. High level of provision with road network does not always indicate high quality of the roads. Among the administrative centers of the CFD, Belgorod and Tambov are leaders in the road surface quality, where the proportion of roads with the improved hard surface is 100% and 95%, respectively. Comparatively low indicators are in Bryansk (60% of the total length of hard-top roads), Voronezh (66%), Orel (66%) and Tver (67%). Population polls show that the quality of roads is highly appreciated by Belgorod (73.2%) and Kaluga (69%) residents. Tambov (24.6%), Orel (25.9%) and Tver (28%) fell into the group that lags behind in the city roads quality with a low degree of population's satisfaction with the state of the road facilities.

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5. RESULTS OF THE ASSESSMENT OF DEVELOPMENT OF COMMUNAL INFRASTRUCTURE IN THE CITIES OF THE CFD

The system of communal infrastructure is a set of engineering and technology facilities and structures used in the electricity, gas, heat, water and sanitation industries to meet the needs of the city's population. Managing the urban system of communal infrastructure is aimed at providing the population with utilities of the standard quality at an affordable cost, as well as ensuring reliable and sustainable operation of communal facilities. The state of the urban systems of communal infrastructure in the cities of the CFD for 2015 is shown by the statistical data presented in Table 3.

TABLE 3 - STATISTICAL DATA ON THE STATE OF COMMUNAL INFRASTRUCTURE IN THE CITIES OF THE CFD FOR 2015

Indicator	Belgorod	Bryansk	Vladimir	Voronezh	Kaluga	Lipetsk	Orel	Ryazan	Smolensk	Tambov	Tver
Total length of streets, km	654.2	818.7	375	1,454.4	690.5	539.9	457.6	540	383.4	373.1	580.2
Total length of illuminated parts of streets, km	536.2	790.8	375	1,307.4	565	500.8	380.2	446.5	376.9	373.1	557
Length of heat and steam networks, thous. m.	354.9	585	363.2	820.7	560.7	2,225.1	265.7	696.5	430.3	470.9	484.1
Length of heat and steam networks in need of replacement, thous. m.	94.2	22.2	113.3	168.6	27.6	753.5	132.1	77.7	248.7	181.8	318.4
Heat and steam networks replaced, m	2,100	11,800	4,900	13,700	24,800	7,700	514	6,500	13,800	0	21,400
Length of street water supply network, thous. m.	756.3	623.3	424.5	1,110.9	406.9	571.4	317.8	281.6	275.1	423.56	268.3
Length of street water supply network in need of replacement, thous. m.	265.8	175.7	84	505.8	16.2	340.9	60	65.8	115.1	27.7	178.1
Street water supply network replaced, m	6,600	3,000	2,000	3,100	1,000	800	2,700	300	1,900	100	0
Length of sewage network, thous. m.	275.3	177.4	171.2	488.8	157.8	258.9	190.3	188.5	183.8	221.5	116.8
Length of sewage network in need of replacement, thous. m.	12.29	60.6	26	313.1	14.8	120.1	96.4	121.7	36.8	110	68.9
Street sewage network replaced, m	400	0	300	2,100	1,100	0	400	200	400	100	0
Length of street gas network, thous. m.	751.5	1,191.5	1,140.75	1,902.8	1,083.2	1,087.7	480.01	755.64	1,181.4	1098	1,150.1
Length of street gas network in need of replacement and repair, thous. m.	0	2.61	0.65	0.272	3.13	1.94	11.63	0.44	0	0	345.02
Street gas network replaced and repaired in the reporting year, m	0	2,610	850.8	272	1,839	1,940	14,078	2,950	0	0	3,322

The level of illumination of streets, driveways and embankments in the administrative centers of the CFD is described by fairly high figures. Vladimir and Tambov are leading, where the length of illuminated streets is 100%; this figure in Kaluga and Belgorod is 81.8% and 82%, respectively.

Ranking of the administrative centers of the CFD by the level of illumination of streets, driveways and embankments at year-end 2015 is shown in Figure 2.

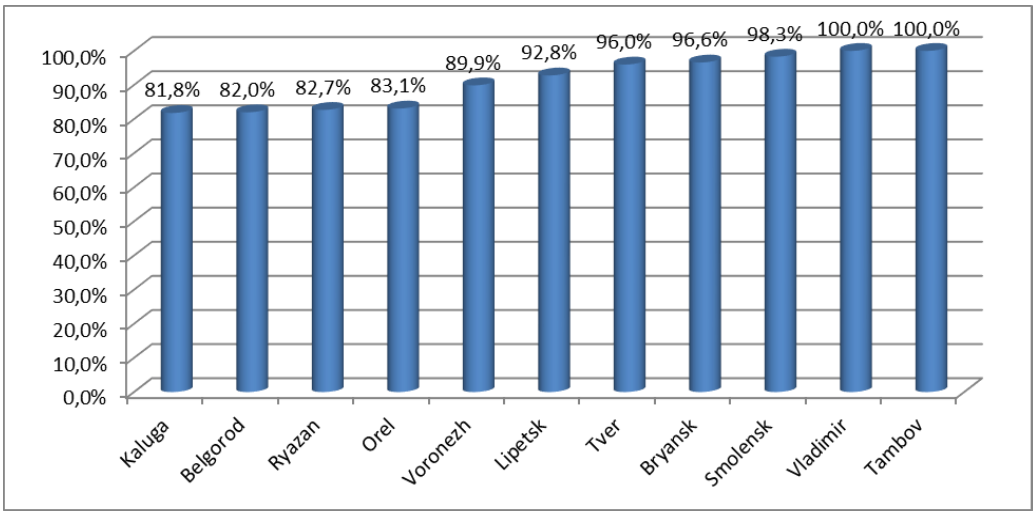

FIGURE 2 - RANKING OF THE CFD CITIES BY THE LEVEL OF ILLUMINATION OF STREETS, DRIVEWAYS AND EMBANKMENTS AT YEAR-END 2015

A study of the state of the cities' communal infrastructure reveals that the highest level of technical serviceability is observed in gas networks: this indicator exceeds 90% in all administrative centers (except for Tver). The results of calculation of the indicators of technical serviceability of communal networks by the administrative centers of the CFD are shown in Table 4.

TABLE 4 - INDICATORS OF TECHNICAL SERVICEABILITY OF COMMUNAL NETWORKS BY THE ADMINISTRATIVE CENTERS OF THE CFD

	Belgorod	Bryansk	Vladimir	Voronezh	Kaluga	Lipetsk	Orel	Ryazan	Smolensk	Tambov	Tver
Level of technical serviceability of heat and steam networks	73.5%	96.2%	68.8%	79.5%	95.1%	66.1%	50.3%	88.8%	42.2%	61.4%	34.2%
Level of technical serviceability of water supply networks	64.9%	71.8%	80.2%	54.5%	96.0%	40.3%	81.1%	76.6%	58.2%	93.5%	33.6%
Level of technical serviceability of sewage networks	95.5%	65.8%	84.8%	36.0%	90.6%	53.6%	49.3%	35.4%	80.0%	50.3%	41.0%
Level of technical serviceability of gas networks	100.0%	99.8%	99.9%	100%	99.7%	99.8%	97.6%	99.9%	100.0%	100.0%	70.0%

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There are considerable differences in the levels of technical serviceability of communal networks: this indicator for the state of heat networks varies from 34.2% (in Tver) to 96.2% (in Bryansk). The leaders in terms of technical serviceability of water supply facilities are Kaluga (96%) and Tambov (93.5%). Low indicators of serviceability of water supply networks belong to Tver (33.6%) and Lipetsk (40.3%). Belgorod (95.5%) and Smolensk (80%) are leading in terms of technical serviceability of sewage networks. Outsiders by this indicator are Ryazan (35.4%) and Voronezh. It must be noted that the level of upgrade of the communal infrastructure is low almost in all administrative centers (Table 4).

TABLE 4 - LEVEL OF UPGRADE OF THE COMMUNAL INFRASTRUCTURE IN THE CITIES OF THE CFD FOR 2015

Indicator	Belgorod	Bryansk	Vladimir	Voronezh	Kaluga	Lipetsk	Orel	Ryazan	Smolensk	Tambov	Tver
Level of upgrade of heat and steam networks, %	0.6 %	2.0 %	1.3 %	1.7 %	4.4 %	0.3 %	0.2 %	0.9 %	3.2 %	0.0 %	4.4 %
Level of upgrade of water supply networks, %	0.9 %	0.5 %	0.5 %	0.3 %	0.2 %	0.1 %	0.8 %	0.1 %	0.7 %	0.0 %	0.0 %
Level of upgrade of sewage networks, %	0.1 %	0.0 %	0.2 %	0.4 %	0.7 %	0.0 %	0.2 %	0.1 %	0.2 %	0.0 %	0.0 %
Level of upgrade of gas networks, %	0.0 %	0.2 %	0.1 %	0.0 %	0.2 %	0.2 %	2.9 %	0.4 %	0.0 %	0.0 %	0.3 %

The population's satisfaction with the services of the city's communal utilities is one of the most important criteria for assessing the operation of the urban communal economy (Figure 3).

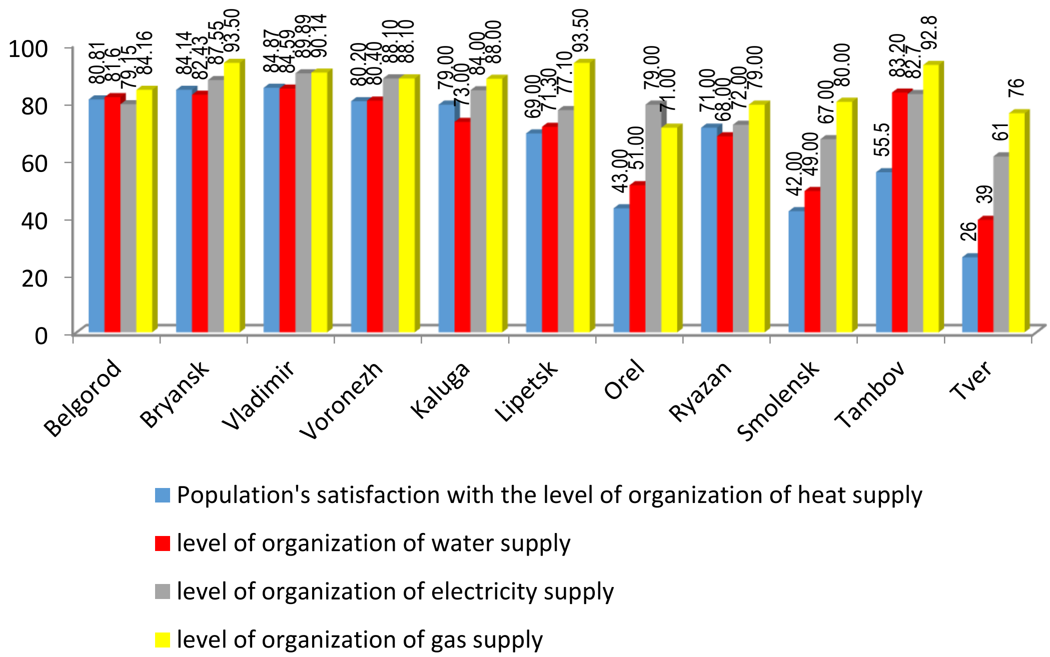

FIGURE 3 - LEVEL OF THE POPULATION'S SATISFACTION WITH THE SERVICES OF THE CITY'S COMMUNAL UTILITIES IN THE ADMINISTRATIVE CENTERS OF THE CFD IN 2015

According to population polls, a low level of the population's satisfaction with heat services was recorded in Tver – only 26% of the polled population of the city. High level of the population's satisfaction with heat supply was recorded in Bryansk (84.1%) and Vladimir (84.9%).

6. RESULTS OF THE ASSESSMENT OF THE COMPREHENSIVE DEVELOPMENT OF URBAN INFRASTRUCTURE OF THE ADMINISTRATIVE CENTERS OF THE CFD

Results of calculations of the index of the road infrastructure development in the administrative centers of the CFD are shown in Table 5.

TABLE 5 - INDICES OF THE ROAD INFRASTRUCTURE DEVELOPMENT IN THE ADMINISTRATIVE CENTERS OF THE CFD

Indicator	Belgorod	Bryansk	Vladimir	Voronezh	Kaluga	Lipetsk	Orel	Ryazan	Smolensk	Tambov	Tver
Density of the road network km/thous. sq.km. of the territory	0.82	1.00	0.00	0.44	0.35	0.15	0.81	0.29	0.36	0.73	0.82
Provision with gas stations, units per 100 km of roads	0.82	0.50	0.78	0.00	0.79	0.90	0.13	0.83	0.92	1.00	0.81
Proportion of hard-top roads in the public road network	1.00	0.00	0.97	0.06	0.58	0.44	1.00	0.64	0.69	0.86	0.56
Proportion of roads with improved surface	1.00	0.00	0.98	0.15	0.63	0.50	0.15	0.68	0.25	0.88	0.18
Level of the population's satisfaction with the quality of roads, %	1.00	0.27	0.62	0.21	0.91	0.16	0.03	0.09	0.09	0.00	0.07
I_{ri}	0.93	0.36	0.67	0.17	0.65	0.43	0.42	0.51	0.46	0.69	0.49

It can be seen from Table 5 that Belgorod has the most developed and high-quality road infrastructure. Tambov and Vladimir rank second and third. Voronezh ranks last. Calculation of the index of the communal infrastructure development in the administrative centers of the CFD is shown in Table 6.

Next, the index of the urban infrastructure development Iui is calculated, after which the administrative centers are ranked in descending order. Attention is drawn to the fact that infrastructure development is strongly correlated with the sustainable development of cities. For example, according to the ranking of sustainable development of the cities of the Russian Federation for 2015, compiled by the SJM Agency, Belgorod, Kaluga and Vladimir are also the leaders by the ISD index among the administrative centers of the CFD (Table 7).

Ranking results indicate that the infrastructure development of most of the cities of the CFD is below average. According to the obtained results, three groups of administrative centers with different levels of infrastructure development can be distinguished.

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TABLE 6 - INDEX OF THE COMMUNAL INFRASTRUCTURE DEVELOPMENT IN THE CFD CITIES IN 2015

Indicators	Belgorod	Bryansk	Vladimir	Voronezh	Kaluga	Lipetsk	Orel	Ryazan	Smolensk	Tambov	Tver
Level of upgrade of heat and steam networks, %	0.14	0.45	0.30	0.39	1.00	0.07	0.05	0.20	0.73	0.00	1.00
Level of upgrade of water supply networks, %	1.00	0.56	0.56	0.33	0.22	0.11	0.89	0.11	0.78	0.00	0.00
Level of upgrade of sewage networks, %	0.14	0.00	0.29	0.57	1.00	0.00	0.29	0.14	0.29	0.00	0.00
Level of upgrade of gas networks, %	0.00	0.07	0.03	0.00	0.07	0.07	1.00	0.14	0.00	0.00	0.10
Population's satisfaction with the level of organization of heat supply	0.93	0.99	1.00	0.92	0.90	0.73	0.29	0.76	0.27	0.50	0.00
Population's satisfaction with the level of organization of water supply	0.93	0.95	1.00	0.91	0.75	0.71	0.26	0.64	0.22	0.97	0.00
Population's satisfaction with the level of organization of electricity supply	0.63	0.92	1.00	0.94	0.80	0.56	0.62	0.38	0.21	0.75	0.00
Population's satisfaction with the level of organization of gas supply	0.58	1.00	0.85	0.76	0.76	1.00	0.00	0.36	0.40	0.97	0.22
I_{ui}	0.54	0.62	0.63	0.60	0.69	0.41	0.42	0.34	0.36	0.40	0.17

TABLE 7 - DISTRIBUTION OF ADMINISTRATIVE CENTERS OF THE CFD IN THE RANKINGS

Cities	Infrastructure development ranking	cities	Sustainable development ranking
Belgorod	0.74	Belgorod	0.57
Kaluga	0.67	Kaluga	0.56
Vladimir	0.65	Vladimir	0.55
Tambov	0.55	Ryazan	0.55
Bryansk	0.49	Voronezh	0.54
Ryazan	0.43	Lipetsk	0.54
Lipetsk	0.42	Tver	0.53
Orel	0.42	Bryansk	0.52
Smolensk	0.41	Orel	0.52
Voronezh	0.39	Tambov	0.51
Tver	0.33	Smolensk	0.48

The first group – group of leaders – includes Belgorod, Kaluga and Vladimir with indices of 0.74, 0.67 and 0.65, respectively.

The second group – group of the middle-level infrastructure development – includes the majority of the administrative centers of the CFD under study.

Tver and Voronezh are classified as outsiders in terms of the level of the urban infrastructure development.

7. MECHANISMS OF IMPROVING THE EFFICIENCY OF THE URBAN INFRASTRUCTURE

Underdevelopment of the urban infrastructure remains one of the major problems of Russia, while comfortable life in cities remains an unattainable dream for many Russians.

In the opinion of municipal authorities, insufficient funding of measures for modernization of infrastructure facilities is one of the main constraints to the development of urban infrastructure in most cities. At the same time, the search for and diversification of investment sources for updating road and communal infrastructure are an urgent task of municipal administration.

Budget funds are traditionally spent on the construction of urban infrastructure facilities within the framework of targeted programs or investment targeted programs. Municipal programs for the road and communal infrastructure development are one of the effective mechanisms to manage the urban economy and are a guarantee of timely funding of measures to develop and upgrade the engineering systems of the housing communal complex.

PPP is one of the tools to attract private investment in the upgrade of urban facilities. At the same time, in the opinion of the expert community, the PPP mechanisms at the municipal level are not being used actively enough (Study "Development of public-private partnership in Russia in 2015-2016. Regions ranking by the level of PPP development").

According to a study by Ernst & Young, insufficient guarantees of investment return are one of the main obstacles to invest in the infrastructure projects of Russian cities for investors (Ganelin and Vasin 2014). In the opinion of experts, the growing public debt of the subjects of the Russian Federation has a negative impact on the investment attractiveness of regions and cities.

Creation of a specialized budgetary liability insurance fund on the basis of one of the existing development institutions may become one of the best solutions and ensure stability of local budgets for participation in PPP projects in the long term.

At the state level, it is necessary to develop special mechanisms to subsidize municipal entities for the PPP projects implementation. This will allow to refocus the planned infrastructure projects to the PPP rails, along with launching a number of deferred projects.

8. CONCLUSIONS

A modern city is focused on ensuring economic growth, increasing investment and creating new jobs, which will allow to improve the living standards and financial opportunities for managing the urban infrastructure that serves the urban environment. To do this, it is required to understand the fundamental

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concept of sustainable development in order to provide investors with confidence that the arising problems are understandable and can be managed.

Solution of the problems set in the study has allowed the author to formulate the following conclusions:

- The presented methods allow to obtain objective information and quantitative assessment of the infrastructure development of cities and to identify leaders and outsiders to determine their potential. Systematic assessment and ranking of cities by the level of development of urban road and communal infrastructure will allow to improve their competitiveness and to use the best practices.
- There are considerable differences in the levels of technical serviceability of communal infrastructure facilities among the administrative centers of the CFD.
- Quite high development indicators in terms of illumination of streets, driveways and embankments, as well as technical serviceability of gas facilities are observed. At the same time, water supply, sanitation and heat supply facilities are described by a low level of technical serviceability and low rates of upgrade.
- In the context of a deficit in budget funding of upgrade programs for urban infrastructure facilities, a public-private partnership is one of the most efficient instruments for attracting investment in this area.

The results of the conducted study allow to determine the necessary areas for application of forces to the transition to a new level of the urban infrastructure quality, as well as to develop comprehensive programs aimed at sustainable and stable development of urban economy.

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