International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-2, December 2019

Infrastructure and Ecology as Important Systems for Sustainable Urban Development

Indira Lechievna Arsaeva, Elena Evgenevna Mashyanova, Vladimir Dmitriyevich Sekerin, Anna Evgenievna Gorokhova, Sergey Ivanovich Dolgov

Abstract:*A new vision of the global needs of mankind is embodied in the concept of sustainable development, which means meeting the needs of the current generation without compromising the ability to meet their needs by future generations. Today, more than half of the world population lives in cities, the development of which is influenced by many interdependent factors, so there is a need for a clear and holistic approach to sustainable urban development.*

The aim of this paper is to study urban infrastructure in the aspect of its greening as an important component of the sustainable development system of the city.

The paper analyzes the academic literature on the problem of greening urban infrastructure as the basis for sustainable development of the city. The determination of the main elements of green infrastructure and technologies in the field of green infrastructure in foreign countries has been carried out. Particularly significant action strategies for cities have been identified as part of a sustainable development policy.

Keywords**:** *city, infrastructure, ecology, sustainable development, green infrastructure, greening.*

I. INTRODUCTION

The importance of the city and its role in society are constantly growing under the influence of factors such as globalization and urbanization [1]. Already now, studying these phenomena, it is easy to notice that often one is dealing not with a certain number of countries, but with a network of the largest cities, or World Cities [2], which interact more closely than each of them separately with its own country. The city is gaining an increasing influence on the national economy and is increasingly becoming an independent subject of international relations [3].

The role of cities as places of population and production concentration has always been decisive. Cities are considered as centers of economic, scientific, technical and cultural progress and, at the same time, as centers of regional territorial complexes [4, 5].

Revised Manuscript Received on December 30, 2019.
***** Correspondence Author
Indira LechievnaArsaeva*, Chechen State University, Grozny, Russia.
Elena EvgenevnaMashyanova, V.I. Vernadsky Crimean Federal University, Simferopol, Republic of Crimea, Russia.
Vladimir DmitriyevichSekerin, V.A. Trapeznikov Institute of Control Sciences of Russian Academy of Sciences, Moscow, Russian Federation
Anna Evgenievna Gorokhova, V.A. Trapeznikov Institute of Control Sciences of Russian Academy of Sciences, Moscow, Russian Federation.
Sergey IvanovichDolgov, Russian Foreign Trade Academy, Moscow, Russian Federation.

Modern globalization processes have made cities not only economic, political and financial, but also powerful information and communication centers, which determine the pace and rhythm of development of modern civilization. However, along with fulfilling the functions of an engine of progress and a leader in the development of adjacent territories, the purpose of the city is also to be a convenient, cozy and comfortable home for its inhabitants.

Infrastructure is an important factor for the normal functioning of the city, economic development and providing comfortable living conditions for its residents. One of the key tasks of local authorities is the development and implementation of comprehensive programs for managing existing infrastructure facilities and the construction of new ones in accordance with existing needs [6].

The modern development of the infrastructure of Russian cities is an urgent topic, since the components of the infrastructure complex, namely transport, communications, housing and communal services, education, medicine and the recreational system, social security, culture and the environment are some of the most important systems for the "healthy" development of a separate city, a region, and the country as a whole.

II. LITERATURE REVIEW

Studies of sustainable development issues are covered in the works by such Russian and foreign scientists as Bobylev*et al*. [7], Armensky*et al*. [8], Danilov-Danilyan and Piskulova [9], Lele [10], Vare and Scott [11] and others.

In the process of discussing the concept of sustainable development, researchers [12] often distinguish between global environmental threats to human life on the planet, on the one hand, and local problems, on the other hand, which are more consistent and prone to harmonization. In this discussion, cities and urban areas play an important role: urban residents face various economic, social problems, air pollution and low living standards, but at the same time, cities cause most of the global environmental problems; today, about 50% of the world's people live in cities.

In 1995, the European Environment Agency published the main objectives for achieving sustainable urban development:

- minimization of the use of space and natural resources;
- rationalization and optimization of urban governance;
- healthcare for the urban population;
- ensuring equal access to resources and services;
- support for cultural and social diversity [13].

The Leipzig Charter, to ensure the integrated development of European cities, recommends adhering to ten principles of the policy of integrated urban development, which include [14]:

1. ensuring territorial integrity through a more balanced social and economic development of the regions and increasing their competitiveness;
2. stimulating development caused by the performance of urban functions, and improving relations between the city and the village;
3. promoting more balanced transport accessibility;
4. expanding access to information and knowledge;
5. reduction of damage to the environment;
6. value added and protection of natural resources and natural heritage;
7. augmentation of cultural heritage as a factor in the development of European cities;
8. development of energy resources and ensuring energy security;
9. promotion of high-quality sustainable tourism;
10. limiting the impact of natural disasters.

According to researchers, a balanced (sustainable) development of the city involves a combination of economic, social and environmental aspects, which is reflected in the achievement of goals such as: inclusive economic growth; competitive urban economy; social justice and equality; environmental safety; safe, comfortable and reliable living environment [15].

Rai [16] believes that sustainable urban development should include: energy-saving technologies in all areas of activity; conservation of biological diversity (the share of natural territories should be at least 30%); reduction of environmental pollution through the greening of vehicles and industry, and the use of roadside environmental components.

Researchers [17] consider the "green" infrastructure an important component of the implementation of the sustainable urban development strategy as it helps to reduce or level the anthropogenic impact, also contributing to the rational and efficient use of the resources of Earth. In their opinion, a "green" (sustainable) infrastructure is a comprehensive integrated system of interconnected structures and facilities that create an environment for people to live and the economy to function, operating based on the principles of energy saving, energy efficiency, contributing to the rational use of resources, without realizing or minimizing the negative impact to the environment. Among the main components of a balanced infrastructure, scholars distinguish: renewable energy sources; smart buildings; ecological public transport; smart water supply and sanitation systems; rational waste management systems, etc.

According to the definition by Ahern [17], "green infrastructure" is a strategically planned network of natural and semi-natural territories with other environmental characteristics, designed and managed to provide a wide range of ecosystem services, such as water purification, air quality, space for recreation and mitigation of the effects of climate change and adaptation. This is a network of green (land) and blue (water) spaces, which can improve environmental conditions and, consequently, the health and quality of people's life. It also supports the green economy, creates jobs and increases biodiversity.

Coutts and Hahn [18] define "green infrastructure" as a set of planned natural and landscape zones and elements in cities that are maintained in such a way that they provide high quality for ease of use, biodiversity and aesthetic appearance, and a wide range of ecosystem services. Moreover, any vegetation, embossed surfaces and individual elements can be components of "green infrastructure" regardless of ownership and formation.

According to the concept of "green infrastructure" by Gidlow and Ellis [19], the model of a green city is characterized by the minimization of the negative human impact on the environment in accordance with the principles of sustainable development of the territory. This goal can be achieved through a comprehensive environmental policy that includes not only individual environmental measures, but also the greening of all elements of the city's infrastructure, and especially the introduction of environmental thinking and lifestyle among residents.

Research hypothesis: the main factors in modernizing urban infrastructure for sustainable development are: environmental (maintaining and improving the environment), economic (saving and rational use of the urban environment and its resources), socio-cultural (creating favorable conditions for life and restoring the urban environment), engineering (creating a convenient street-road network, as well as engineering protection of territories), innovative and technological (introducing new technologies that contribute to essential services for individuals and management of surrounding area).

III. PROPOSED METHODOLOGY

A. General Description

In the research process, such research methods were applied as:

- an analysis of academic literature on the role of infrastructure and ecology in the system of sustainable development of the city.
- an expert poll in order to identify the main characteristics of the city's "green infrastructure" (elements, green infrastructure technologies), directions for the greening of the urban environment and action strategies within the framework of a sustainable urban development policy.

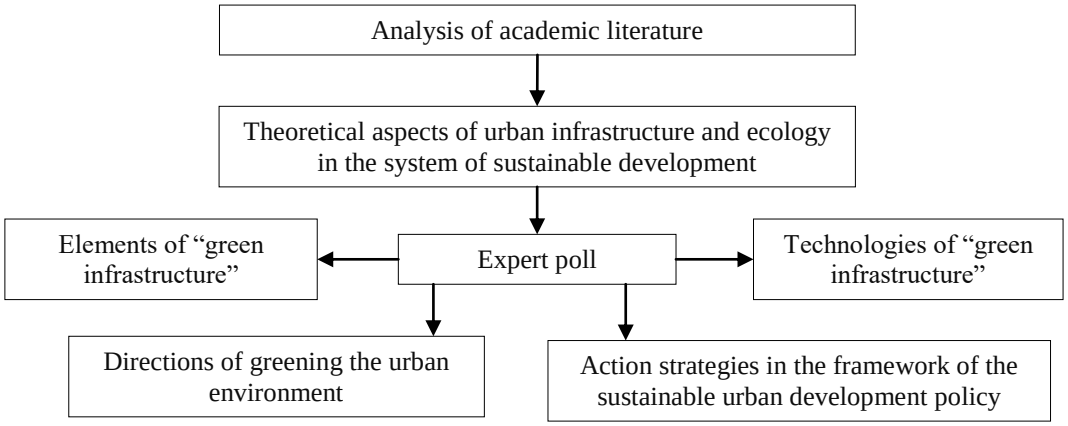
Twenty-eight experts took part in the online survey: employees of economic and political science departments of universities.

B. Algorithm

At the first stage of the study, an analysis of the academic literature on the role of infrastructure and ecology in the system of sustainable urban development was carried out.

At the second stage of the study, elements of the "green infrastructure" of the city and related technologies, directions of greening the urban environment and action strategies in the framework of the sustainable urban development policy were identified.

C. Flow chart



IV. RESULT ANALYSIS

The expert poll showed that "green infrastructure" can provide a range of social, economic and environmental benefits, therefore it is advisable to consider the broader concept of "environmental management infrastructure", by which experts understand the set of organizational, technical, socio-economic and socio-environmental measures to create safe living conditions for people and the city as a whole. These activities include territory planning in terms of accessibility for people and aesthetic appearance: landscaping, creation of noise and gas shields to protect against acoustic and gas pollution, as well as state funding for these activities.

According to experts, the main results of urban "green infrastructure" are: developed green areas, such as parks, allotments, natural playgrounds; various technologies in the field of environmental management; so-called "green streets".

The main directions of development of the elements of "green infrastructure" are presented in Table 1.

Table 1. "Green infrastructure" elements

"Green infrastructure" elements	% of mentions
Green building: thermostats, LED lighting, rainwater collectors, water recycling systems, the principle of "reducing consumption, recycling and processing"	86%
Green waste management	82%
Green transport routes and corridors	75%
Green transport (electric buses and hybrids)	71%

Trends in the development of "green infrastructure" can be characterized using a variety of technologies in the field of environmental management.

Technologies in the field of "green infrastructure" are presented in Table 2.

Table 2. "Green infrastructure" technologies

Technology	Description
Photocatalytic paving of streets.	Cleaning the outside air by removing toxic substances that got into it through the emissions of vehicles. When exposed to sunlight, a chemical reaction of titanium dioxide with nitric oxide is formed, while nontoxic nitrates are formed, which are washed off when it rains.
LED Lighting	LEDs are the latest technology in lighting. They are distinguished by long-term life (from 30,000 to 60,000 hours) and extremely energy-efficient use in relation to conventional incandescent lamps. They produce little heat and are made from nontoxic materials that can be recycled. LED lights provide excellent visibility and reduce environmental pollution.
Solar PV panels	Photovoltaic panels use sunlight and turn it into usable energy. They can be used to power streetlights, parking meters and transit stops and as decorative paving. They have a significant advantage over conventional power systems due to energy efficiency and wireless control.
"Solar Roads"	A new technology that is being developed and implemented in the USA. It is a street paving system with photovoltaic panels that are designed to convert sunlight into energy. Solar roads are designed as a comprehensive product that will eliminate repainting requirements and even winter maintenance.
"Cool sidewalks"	Sidewalks with higher reflectivity reduce the effects of heat which is carried into storm water.
Biotope mapping	The purpose of biotope mapping is to describe the landscape based on the identified types of biotopes.
Green routes	They connect residential areas (remote from the "busy roads") with places for recreation, and at the same time, they offer a "green alternative" to car traffic.
Green roof systems TOPGREEN	Designed to bind and filter pollutants and absorb airborne sound, they also protect the building from hail. They have thermal insulation properties.
SolarVert Systems	Combining solar panels with green roofs leads to important synergistic effects. The plant layer takes the necessary load to protect it from the effects of wind.

Note: complied upon the expert poll results

Thus, the concept of the city's green infrastructure includes such a concept as the model of the "green city", which is characterized by minimizing the anthropogenic impact on the environment in the framework of sustainable development of the territory and taking measures to save resources.

This goal can be achieved through a comprehensive environmental policy, which includes the greening of all elements of the city's infrastructure and the implementation of environmental thinking.

V. DISCUSSION

Starting to discuss the results of the study, experts noted that the quality of life in large Russian cities is declining due to environmental problems. The situation in the development of the urban environment is worsening: the growth in housing construction, the construction of office buildings, shopping and entertainment malls, characterized by high investment efficiency in big, large and largest cities. Excessive haste in the development of urban areas reflects the desire of investors, as well as city authorities, to receive the maximum today's benefits at all costs. At the same time, the public interests and the environmental problems in the development of urban areas, at times, are not taken into account.

According to experts, such a development of the urban environment can lead to many problems: reconsolidation of cities (especially in the historical center), transport congestion, destruction of cultural heritage sites, lack of an attractive environment and a sharp decrease in comfortable ecological characteristics. In such conditions, it is necessary to develop a concept for the greening of urban infrastructure.

Such a concept, according to experts, should, first of all, take into account the specifics of the formation of the urban environment. As experts point out, in Russia the urban environment is a multilevel hierarchical system as the city is a concentration of economic, managerial, social, energy and other activities of society. In the urban environment, integration of all types of activities and their corresponding facilities is carried out using urban infrastructure, which, according to one of the experts, "represents the spatial planning organization of residential, industrial, landscape and recreational entities using transport and pedestrian communications and their unification with the downtown".

According to experts, transport communications are the most stable element of this structure, retaining the functional significance even with global changes in organizing the urban environment. They are the most aggressive components of urban infrastructure and should be prone to greening, taking into account their spatial content according to environmental and functional requirements. Transport and pedestrian infrastructure should be organically linked with the downtown. In Russian cities, the downtown is a comprehensive infrastructure with specific features of the organization. For the purposes of greening the urban environment, according to experts, it is necessary to improve the formation of the industrial infrastructure of the city, i.e. the whole set of industrial areas and particular industrial enterprises interconnected through transport and pedestrian communications. The infrastructure of the living environment in cities, experts say, is a comprehensive hierarchical system that organically forms the planning and spatial structure of the city, created in the process of evolutionary development of the urban environment, continuously being improved taking into account economic and technical capabilities, according to the general plans for urban development of the city, but today it has certain disadvantages. According to experts, in order to green the urban environment, it is advisable to restructure the living environment taking into account the natural component. The structure of all types of residential formations should include elements of the natural environment – vegetation, water devices, elements of geoplastics – to improve their ecological and aesthetic characteristics, and residential buildings should be as close as possible to landscape and recreational facilities of the city. According to experts, the landscape and recreational infrastructure in Russian cities was also created during the historical development of the urban environment, including both artificially created elements and natural elements that today need renovation. Experts attribute the deterioration of the natural component to the problems of the current stage of urban environment development, as large and largest cities have exhausted their natural resources and are experiencing an acute shortage of recreation facilities, territories suitable for recreation, and restoration of the psychophysical strength of a person. At the same time, due to intensive urbanization and population growth, the load on public comfortable recreational areas in the city increases. Therefore, according to experts, the importance for each resident and the city as a whole of previously created landscape objects, especially city parks as the most important link in the citywide landscape system, is steadily increasing. At the same time, the situation is complicated by destructive environmental factors that affect the state of landscape and recreational facilities (the negative impact of vehicles, industry, etc.). All these shortcomings, as opined by experts, require a restructuring of the infrastructure of landscape and recreational facilities in the city to create a comfortable environment by ecological, functional and aesthetic parameters. Thus, as experts say, for the greening of the urban environment, it is necessary, first of all, to analyze the existing infrastructure according to the main indicators of its comfort, taking into account the spatial needs of a person (environmental, functional, aesthetic, social) and identify the examples of negative impact on it with the subsequent determination of techniques for their elimination. Such an analysis should also take into account the trends of sustainable urban development, since cities in Russia should develop according to the laws of sustainable development.

According to experts, the following action strategies are especially important for cities in the framework of sustainable urban development policies:

- creation and maintenance of quality public areas. The quality of public spaces, urban cultural landscapes, architecture and urban planning play a central role for the specific living conditions of urban residents. Besides, as "soft" factors affecting the choice of production locations, public areas are important for the functioning of knowledge economy enterprises, for attracting qualified and creative labor resources, as well as for tourism. Public areas and green spaces exist in almost all European cities, creating attractive views and increasing the comfort of living there, facilitating their further development. The practice of sustainable development of European cities shows that cities can be divided into certain zones according to their functions and purposes,

the state of the environment and other criteria, for example, in a city the following can be distinguished: social zones – urban areas intended for housing; areas of potential economic development – intended for the production and conduct of business; public areas – the downtown, the central pedestrian zones and other areas with a possible concentration of public space functions [20];

- modernization of infrastructure networks and an increase in their energy efficiency. Reliable and easily accessible systems of urban transport, primarily environmental, make a significant contribution to ensuring the desired quality of life and the environmental quality. In this regard, according to experts, much attention needs to be paid to transport management and coordination of all types of transport, including pedestrians' and cyclists' traffic. Urban transport should be in harmony with the problems of citizens' living, their work, environment and public areas. For this, it is necessary, first of all, to improve the technical infrastructure in a timely manner, in particular water supply, sewage water treatment and other communication networks of the urban utilities, to adapt them to the changing needs in such a way that in the future they can help ensure a high quality of urban life. The essential prerequisites for social infrastructure in the field of supply and utilization, as experts say, are energy efficiency, saving of natural resources and economic efficiency of their use. It is impossible to build a transport system of a city without updating or reconstructing urban water supply and sewerage networks, drains, and heat supply networks. This is a prerequisite for the implementation of sustainable urban development and this will help create a convenient transport infrastructure with minimal environmental impact.

VI. CONCLUSION

The versatility of the urban infrastructure is an expression of a new ideology for the formation of an urban environment that is ecologically oriented, including a change in the purpose of the environment: new functions are assigned to historical areas – recreational, educational, educational; city streets and squares are organized as walking, exhibition and playground spaces.

The considered concept of "green infrastructure" is based on the principles of sustainable development of an urban territory, according to which the model of the green city is characterized by the minimization of negative anthropogenic impact on the environment. By "green infrastructure", which needs to be developed, taking into account the experience of developed countries, the authors mean a set of organizational, technical, socio-economic and socio-environmental measures to create a safe environment for the existence of people and the city as a whole.

Thus, the results of this study confirm the hypothesis that the main factors of modernization of urban infrastructure for sustainable development are as follows: environmental (conservation and improvement of the environment), economic (saving and rational use of the urban environment and its resources), socio-cultural (creation of favorable conditions for life and recreation of the urban environment), engineering (creation of a convenient street-road network, as well as engineering protection of territories), innovative and technological (introduction of new technologies that contribute to the life necessities of people and the management of the surrounding space).

REFERENCES

1. Y.M. Rogatnev, O.S. Scherba, O.S. Nazarova, T.A.Filippova, O.N. Dolmatova, "Spatio-Temporal Zoning of the Urban Lands' Functioning for Ensuring the Sustainable Development of the City", Journal of Environmental Management and Tourism, 10(1), 2019, 210-219.
2. J.V. Beaverstock, P.J. Taylor, R.G. Smith, "A Roster of World Cities", Cities, 16(6), 1999, pp. 445-458.
3. G.I. Novolodskaya, E.Y. Chicherova, L.A.Ponkratova, N.A.Gracheva, S.V.Ilkevich, "Investing in Human Capital in Tourism Companies", Journal of Environmental Management and Tourism, 10(2), 2019, pp. 340-345.
4. S.R.Safaeva, D.A. Ishankhodjaeva, N.A. Juraeva, O.E.Matyunina, "Economic and Legal Aspects of Tourism Regulation in the New Economy: International Practice", Journal of Environmental Management and Tourism, 10(2), 2019, pp. 459-463.
5. B.A.Mustafayeva, S.A.Kaltayeva, A.A. Saparova, E.A.Alimkulova, M.Kulbayeva, "The Impact of Agricultural Environmental Pollutions on the Population's Quality of Life", The Experience of Kazakhstan. Journal of Environmental Management and Tourism, 10(1), 2019, pp. 161-170.
6. E.S.Akhyadov, E.A. Smirnova, N.V.Oshovskaya, A.G. Panova, D.D. Khairullina, "Digital Economy: Investing in Digital Learning Technologies", International Journal of Engineering and Advanced Technology, 9(1), 2019, pp. 6570-6576.
7. S.N.Bobylev, E.V.Girusov, R.A.Perelet, "Ekonomikaustoichivogorazvitiya" [The Economy of Sustainable Development]. Moscow: Stupeni, 2004, p. 330.
8. A.E.Armensky, S.E.Kochubey, V.V. Ustyugov, "Ekonomikaustoichivogorazvitiya: proryvnyeideiitekhnologii" [Sustainable Development Economics: Breakthrough Ideas and Technologies]. Moscow: Sotsialnyiproekt, 2009, p. 424.
9. V.I. Danilov-Danilyan, N.A. Piskulova, "Ustoichivoerazvitie: Novyevyzovy": Uchebnikdlyavuzov [Sustainable Development: New Challenges: A Textbook for High Schools]. Moscow: Aspekt Press, 2015, p. 336.
10. S.M.Lele, "Sustainable Development: A Critical Review", World Development, 19(6), 1991, pp. 607-621.
11. P.Vare, W. Scott, "Learning for a Change Exploring the Relationship between Education and Sustainable Development", Journal of Education for Sustainable Development, 1, 2007, pp. 191-198.
12. E. Holden, K.Linnerud, D. Banister, "Sustainable Development: Our Common Future Revisited", Global Environmental Change, 26, 2014, pp. 130-139.
13. Sustainable Development in the European Union. 2016. Available at: https://ec.europa.eu/eurostat/documents/3217494/7745644/KS-02-16-996-EN-N.pdf
14. Leipzig Charter on Sustainable European Cities. 2007. Available at: https://2030.zhitomir.ua/upload/iblock/929/9292d18aa2382e619d2eb8925defb7dc.pdf
15. S.E. Prokofiev, N.KPopadyuk, O.S. Semkina, "Novyepodkhody k razvitiyugorodoviaglomeratsii" [New Approaches to the Development of Cities and Agglomerations]. In Upravlenieustoichivymrazvitiem [Management of Sustainable Development]. St. Petersburg: Izdatelskiy Dom "RealnayaEkonomika", 2015.
16. P.T. Rai, "Townships for Sustainable Cities", Procedia – Social and Behavioral Sciences, 37, 2012, pp. 419-428.
17. J. Ahern, Green Infrastructure for Cities. The Spatial Dimension. InCities of the Future. Towards Integrated Sustainable Water and Landscape Management. London: IWA Publications, 2007.
18. C. Coutts, M. Hahn, "Green Infrastructure, Ecosystem Services, and Human Health", International Journal of Environmental Research and Public Health, 12, 2015, pp. 9768-9798.
19. C.J.Gidlow, N.J. Ellis, "Neighbourhood Green Space in Deprived Urban Communities: Issues and Barriers to Use", Local Environment, 16(10), 2011, pp. 989-1002.
20. S. Kolte, A. Kandya, K. Lakhtaria, V. Patel, P. Ghosh, P. Singh, H. Morabia, "Evolving Sustainable Cities through the Fabric of Technological Transformation", Procedia Engineering, 51, 2013, pp. 480-486.