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Guidelines for "Blue-Green" Urban Infrastructure: Adaptive Model and its Structural Elements

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Abstract. An author's methodological approach has been developed, based on the planning of a "blue-green" urban infrastructure for the conditions of a riverside city, as one of the possible ways to adapt settlements to climate change. An adaptive model of the "Blue-green" infrastructure of a riparian city is proposed, as well as a typology of its structural elements, purposes, and methods of application. This methodological approach develops certain provisions of the Sponge Cities practical urban planning strategy, applicable for versatile climatic conditions and successfully implemented since the 2000s in several Asian countries (Singapore, China, etc) and many European cities.

Keywords: «blue-green» urban infrastructure, adaptive model, riverside or riparian city (settlement)

Introduction

The modern field of landscape architecture (LA) theory and practice is determined by the multifaceted connections of landscape design with architectural design, urban and regional planning. It covers the organization of garden and park landscapes, the formation of urban open spaces, the planning of large open areas of regions as well as the state as a whole. Today, the LA is aimed at intensifying efforts to support the biosphere and solving current problems related to climate change, environmental protection, and biodiversity preservation, combined with the improvement of human living conditions. These facts are confirmed by the numerous new directions and practical urban strategies such as, for example, Green Architecture [40], Responsible Landscapes [7], Resilient Cities [30; 37], Sponge Cities [41], and even Smart Cities and Smart Water Landscaping. The main aim of these projects and their practical realisations is to create working landscapes in urban surroundings taking into account the natural laws of the existence of ecosystems of natural landscapes.

A number of declarative documents, developed and adopted by the international community in the last decade, clarify and concretize different sides and aspects of one of the most challenging global problem - the irreversible climate changes in our planet, which is, in particular, tightly associated with CO_2 emissions into the atmosphere.

In this way, the 2030 Agenda for Sustainable Development and the following declarative documents of humanity such as, for example, The New Urban Agenda "Quito Declaration on Sustainable Cities and Human Settlements for All" (HABITAT III, 2016) - the result of the last global summit on urbanization - is devoted to shaping the implementation of the Sustainable Development Goals and the Paris Agreement on climate change for all kinds of urban forms (such as cities, towns, and village, etc.). This document determines global standards of achievement in sustainable urban development, rethinking the way we build, manage, and live in cities [31].

So, the main goal of all these documents and political efforts is to achieve sustainable and inclusive urban prosperity and opportunities for all. To this degree, the UN Sustainable Development Goals (SDG) 2030 Agenda outlines several issues related to the water component of the landscape. Taking into consideration the point of view of the water environment and the water component of the landscape, it pays special attention to the problems of conducting the «sustainable management of our planet's natural resources (conservation and sustainable use of oceans and seas, freshwater resources …. and to protect biodiversity, ecosystems and wildlife); substantially increasing of the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change; providing the universal access to «safe, inclusive and accessible, green and public spaces» [33]. That is why the harmonious interaction between areas of human settlement and the water environment in the world of climate change is now among the most urgent objectives.

In the author's concept of architectural-landscape interaction of coastal and water areas during their planning integration, which enables the development of modern urban planning strategies of planning organization and adaptation to climate change of ecologically vulnerable coastal zones, the contact zones of land and water environment. As a way of understanding the "phenomenon of water" in nature, in landscape architecture, and urban planning the paradigm of mutual complement and modern interaction of coastal and water areas is formulated, which identifies the changes in society's attitudes towards natural water bodies [21; 23]. In this way, the coastal areas can be divided into seaside, riverside (or riparian), and lakeside areas in the most general way. In turn, the water areas are considered as territories covered by the waters of natural water bodies (in the composition of the water surface, the water column, and the underwater part of the shore), which are the object of architectural and landscape design and development; it was established that the boundaries of water territories should be determined from the water cut (in the boundary period or from the line of the greatest low tide along the shore) towards the water space and regulated by international and domestic legislation; according to the types of natural water bodies, lake, river and sea water territories are distinguished; these areas are designed independently or in conjunction with coastal areas [23; 25].

In the author's scientific research one of the models, «blue-green» infrastructure of coastal and water areas for the conditions of riverside settlements, is drawn up [21; 22; 23].

Literature Review

Considering the increasing role of landscape and green architecture in addressing the issues of adaptation of settlements to climate change, modern urban planning practice considers the issues related to the water component of the landscape as topical. The availability and free access to drinking water, which have always been at the heart of human evolution since prehistoric times [13], and today are the prevailing factors in the organization of modern life on the planet. The right to free access to clean drinking water as a necessity to sustain life is enshrined by the United Nations General Assembly (Resolution 64/292, 2010) [32].

Therefore, the practice of water-sensitive urban planning in Europe, Asia, and America demonstrated that there is a radical change in the standards for the architectural and landscape organization of waterside areas, related to various natural water bodies (a sea, a river, a lake) as well as an artificial one (a pond, a canal, a reservoir, etc) [1; 14; 18; 39]. New standards are aimed at developing adaptive planning measures for climate change, for the sustainable development of areas, and for the priority of natural and environmental aspects, which find their realization into practice in such countries as The USA, The United Kingdom, Canada, Spain, Belgium, France, China, Singapore and others [6; 10; 34; 38].

Given the latest trends in climate change, the state of the planet's water environment, and the need to preserve and restore freshwater resources, as a factor of life support for more than 8 billion people on Earth, it is vital to present the practical strategies, which would be aimed at solving the urgent environmental and urban planning tasks facing modern urban planning and landscape practice and related to the water environment and directly to the water component in the conditions of climate change. All these works are aimed at the complex process of discovering innovative approaches in urban planning of areas together with natural water bodies aimed at supporting water ecosystems and implementing adaptive measures for irreversible climate change by landscape and engineering methods.

In this context, the practical development strategy of Sponge City utilizes the principles of passive absorption, purification, accumulation, and use of precipitation (rainwater) in an environmentally friendly way reducing runoff threats and pollution. Sponge cities began to be widely developed since 2000 in countries such as China [17; 28; 41] and Singapore [27; 41], and several individual projects were implemented in the USA [24]. In Singapore, several ecological park projects have been implemented (since 2006) within the framework of the country's water resource purification program "Active, beautiful and clean water" [27; 41]. These are, for example, the parks "Bishan-Ang Mo Kio Park" and "Kallang River-Bishan Park" (2009-2012), the organization of which contributed to the removal of a concrete tray from the mouth of the Kallang River, the restoration of its natural ecosystem, the creation of green spaces and park areas, disposal of dismantled concrete (when creating bridges, observation towers, etc.) [4; 5]. Several projects have also been implemented in China [35; 36].

Identification of various organizational methods of "interaction" between the river and the city - in particular - the planning of a regional park along the river valley through the city and its suburban area; the organization of the "blue-green diameter" (belt) of the city as a system of historical parks, historical and modern buildings on both banks, pristine natural islands in the river valley; the formation of a system of open public spaces along the river, as well as the disclosure of the role of modern art installations in the dialogue between the community, the urban environment and water surfaces and the use of new technologies for creative such dialogue in the modern metropolis, are outlined in the author's publication [26]. The European approach to solving the tasks of cleaning and restoring natural watercourses in urban areas is presented in the

Water Plan of City project for Antwerp, Belgium (2019) [9].

As a response to the challenges of climate change, some countries in Europe, America, and Asia have chosen a clear orientation of their domestic policy on the renewal and protection of ecosystems of natural water bodies, as the basis for improving the overall ecological situation of their urbanized territories.

Topic

The main topic is devoted to the adaptation of the urban structure to climate change regarding new planning approaches in landscape architecture that can involve water bodies and open green spaces within cities with an already developed planning structure. The location of cities and settlements on rivers is the most common option in urban planning practice in Ukraine. This is also one of the most common cases of the location of cities in the European part of the continent because a significant number of European cities are planned and compositionally related to rivers. The problem of degradation of separate elements of river systems within cities (for example, small rivers or tides, etc.) is particularly acute. Unfortunately, this tendency has already become a characteristic of the urban planning practice of different countries.

Aim and objectives

The paper aims to develop an adaptation model of the "blue-green" infrastructure of a riverside city as one of the bases of the planning method of natural and hydrological protection of territories with their architectural and landscape organization. This goal presupposes the following objectives: a) identify the main problems of the architectural and landscape organization of coastal and water areas; b) develop a model of adaptation measures of architectural and landscape organization of coastal and water areas for the conditions of a riverside city; c) give a typology of structural elements of this adaptation model; d) provide practical recommendations for its application to urban planning practice.

Methodology

The specificity of the object (coastal areas and natural water bodies) and the subject (methodological foundations of the architectural and landscape organization of coastal and water areas) of the study, the complexity, and ambiguity of the problem determined the need for a comprehensive use of general scientific and special urban planning methods used for the research of this area, as well as the development of special research methods and methodological approaches, which are personally proposed by the author.

The work uses an interdisciplinary methodical approach to the study of the research problem involving various fields of professional specialization: landscape architecture, urban planning, architecture, design, hydraulic engineering, etc.; related sciences - geography, geology, hydrology, hydrogeography, limnology, and others. During the research, the following methods were used: statistical, literary, and cartographic analysis of raw data on water ecosystems; planning analysis of urban planning documentation and other materials; method of comparison (theoretical, empirical) of hydrographic and urban planning objects, concepts and terms; method of typological analysis of the country's water fund; system approach method; experimental modeling, visual and graphic analysis, etc. As an analytical basis, the research used: scientific works, literary sources, documents of the Council of Europe; materials and statistical data from the World Resources Institute, International Water Management Institute, Global Water Forum, State Water Resources Agency of Ukraine, State Statistics Service of Ukraine, scientific and project experience of domestic and foreign practice; normative and legislative acts, "Sponge City" strategy, etc., which determine the main directions of international and domestic activity regarding nature protection and urban planning policy about natural water bodies. To systematize and generalize the obtained data, the following methods were widely used in the work - theoretical solution of tasks from abstract to concrete, analysis and synthesis, generalization, concretization, etc.

With the help of methods of analysis (comparative, systemic, critical, analytical) and synthesis, systematization of existing theoretical and practical developments, the main problems of the architectural and landscape organization of coastal and water areas, which arise as a result of both natural and man-made disasters are determined: a) high degree of urbanization of coastal areas, b) vulnerability of water ecosystems, c) acceleration of degradation processes of natural water bodies, d) lack of reliable protection of urban areas from possible natural disasters, d) certain inadequacy of existing approaches to risk planning and management in coastal zones; e) the need to adapt these territories to climate change [23, p.151].

Among the main threats of climate change, related to the water environment of the planet, the following are highlighted: sea level rise, melting of glaciers, natural disasters, regular flooding of territories, and access to drinking water [21, p.164; 23, p.252]. All of them also became true to type for the areas of the European part of the Eurasian continent, as evidenced by such changes in the climatic conditions of the regions as heavy rains, rising water levels in rivers, flooding, sometimes catastrophic and not very expected in the adjacent territories during the off-season (especially in spring), the appearance of dust Boers, which appeared to be characteristic weather phenomenon of many European countries, in particular, in Ukraine during recent decades.

The answer to questions is given in the proposed improved "methodology of architectural and landscape organization of coastal areas", the essence of which is to take into account the following aspects: the basics of engineering and technological solutions (unit 1) related to adaptation requirements to climate change; functional and planning requirements (block 2) and landscape-composition techniques (block 3), which provide for the organization of planning decisions with mandatory consideration of the historical and cultural potential of these territories (block 4). To achieve the "sustainability" of the development of these territories according to modern technological requirements, it is proposed to create a new level of "information and digital control and management" of the coastal territories in the city (block 5) [23].

To achieve the adaptive mobility of project solutions, the methodology of the architectural and landscape organization of coastal areas has been improved in the block of engineering and hydro technological measures due to the development of a new planning method for the natural and hydrological protection of territories. The method is aimed at: a) identifying planning criteria (environmental, systemic, and integration); b) developing planning approach mechanisms, and c) the development of "blue-green" infrastructure, which is considered an alternative to the traditional hydro-technical protection of coastal areas. The essence of the author's proposals is to create a "hybrid" system of protection and use ("exploitation") of coastal urbanized territories. The mechanisms of the methodical approach are divided into planning, "modeling", mathematical, and organizational [22; 24].

The adaptation model of the "blue-green" urban infrastructure was developed as part of the planning method of natural and hydrological protection in order not only to protect built-up areas from prolonged rains, floods, and other natural disasters to minimize its catastrophic consequences and losses through planning measures but also could be designed for the long term – to achieve more sustainable results for water ecosystems, especially – for freshwater ecosystems. In this case, the adaptive model of “blue-green” urban infrastructure, which was developed by the author, shows one possible way of responding to challenges, mentioned above. The proposed model is coherent with the practical urban planning strategy “Sponge City” [17; 28; 41], which expands modern methods and controls resource-saving and territory protection based on innovative technological solutions, and at the same time proposes several implementation measures of architectural andlandscape organization areas for the conditions of a European region with continental climate.

The adaptive model shows the creation of “blue-green” infrastructure of coastal areas in riparian settlements, which provides the following planning and adaptation solutions: a) measures to protect and stop water flow; b) means of passage and absorption of water currents; c) methods of redistribution of water flow; d) preservation of the function of protective strips along the river bed and water protection zone, Fig. 1.

In addition, the structural elements of the adaptation model are (can be): a) “water basins” (for water accumulation, flow regulation, protection of territories); b) “residential groups” (with the functions of absorption and redistribution of water); c) “water gardens” and “wet parks” (with the functions of accumulation, purification, protection); d) “blue streets” (with the functions of redistribution, transportation, regulation of water flow). It is recommended to organize “water pools” both in green areas and in built-up areas, and they can be combined.

The most typical variant of a natural reservoir can be illustrated by the example of a dendropark “Sofiyvka” in Ukraine – a pond located upstream of the river, the riverbed of which serves as a planning axis of the historic garden. This pond serves as the main water basin for water supply to numerous water compositions and jets of the park such as waterfalls, cascades, grottos, fountains, etc [16].
The storage tanks for water have been organized in prominent historical parks as one of the possible options for providing their water system with the required amount of water. Thus, one of the interesting examples from the history of landscape architecture is the historical underground reservoirs of the famous gardens of the Palace of Versailles in France. In 1672 in addition to the existing pools, three underground pools were created directly under the palace terrace. Their total capacity was 34,000 cubic meters of water [15].

Another example of artificial reservoirs is given by modern urban planning practice. In Rotterdam, for example, to redistribute rainwater runoff, the “water square” Benthemplein (Netherlands, 2011-2013) was created. With a total capacity of over 1.7 million liters, it also provides the possibility of gradual “discharge” (within 48 hours) of water into urban watercourses. Upon dry weather, this area functions as a public center with numerous cultural, recreational, and sports facilities [8].

Within the “residential groups,” it is recommended to employ planar greenery landscaping, create “green roofs”, organize “rain gardens” with options to control, redistribute and purify the rainwater, use solid “permeable pavement”, utilize alternative eco-friendly energy sources, etc.

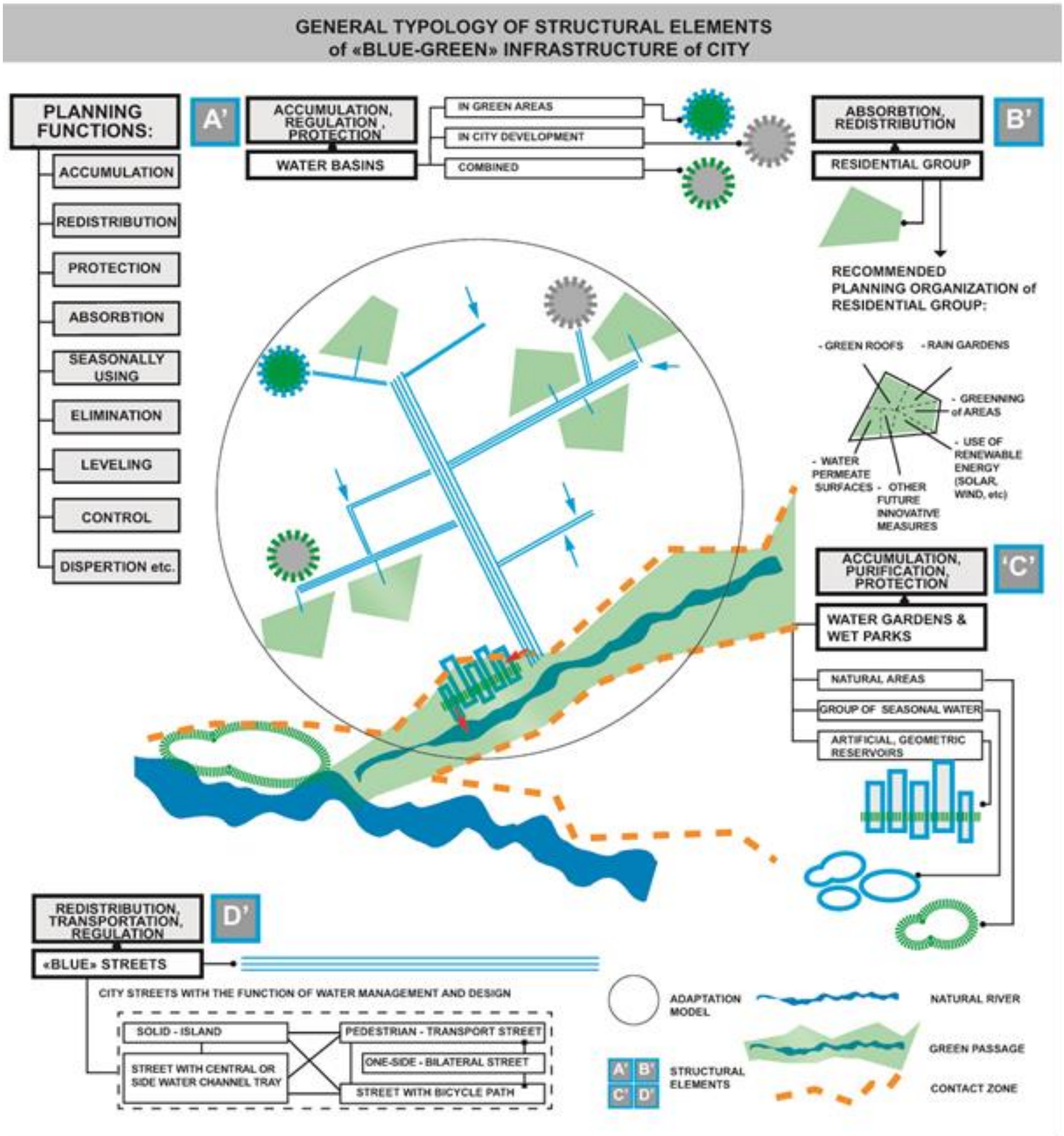

Fig. 1. The adaptation model of "blue-green" urban infrastructure [created by author]

In this aspect, it seems appropriate to look into the past and discover the methods from the practice of past years, such as, for example, the organization of a "tiny garden" in a residential group on the main street facade of the building. Such small gardens, called "polisadnik" in Ukrainian, were widely used in the practice of planning the historic district of Pechersk Lipki in Kyiv City, Ukraine. Many of them are preserved and can be seen today [2].

Green roofs are extremely widely used elements of planning solutions for modern buildings, both for dwelling and public functions. The developed technologies of these gardens are successfully implemented around the world: from grass lawns to vegetable & fruit farms on roofs. It is necessary to emphasize that green roofs are possible to organize for new construction sites as well as for the renewal of existing buildings, including unique sites of urban planning and architectural heritage. For example, in Toronto Downtown, the Banking Pavilion of the first complex of skyscrapers in the city by Mies van der Rohe (today TD Centre) received a green roof in 2009. The new design preserves the original roof grid pattern, which is a protected element of the designated heritage building. Though not publicly accessible, the green roof is visible to TD office workers and visitors from other TD Center skyscrapers [29]. Arranged on another Toronto city complex, Nathan Phillips Square Toronto City Hall Podium Green Roof (2009-2014) feature approximately 36,000 sq. ft. of new green roof, that surrounds the twin towers. This green roof is available to citizens throughout the year [20].

The next structural elements of the model to be discussed are the water gardens and wet parks. Water gardens and wetlands can be natural, in the form of a group of seasonal reservoirs or artificial. Wetlands are typically formed along large rivers, on the shores of large lakes, along the edges of lakes and streams, where they create a transition between

Fig. 2. The water gardens of geometrical shapes of the Haute Deûle River Banks Eco District by Atelier des paysages Bruel-Delma, Lille, France. 2012. Photos and design by Bruel-Delmar [3]

aquatic and terrestrial ecosystems; they are natural water filters, control flooding during prolonged rains, prevent soil erosion, slow global warming, etc. For example, the ecological quarters of the river Haute Deule in Lille have a series of man-made "water gardens" that support natural processes in the local water system (France, 2005-2018) [3, 34], Fig. 2. It is impossible not to mention a new type of city park, which appeared not long ago, in response to ongoing dramatic climate changes. One of the many such examples is the Sherbourne Common City Park in Toronto, Canada, with a "rain management" function: rainwater is collected, purified, and returned to Lake Ontario (2009) [19].

"Blue" streets, as a structural element of the "blue-green" infrastructure of the settlement, are most often urban, green streets with the function of "water management" (for redistribution, transportation, and regulation of water flow). According to their organizational scheme, they can be continuous or have "island" sections, with a central or lateral "water channel-tray", pedestrian or vehicular (one-way or two-way traffic), sometimes arranged with bicycle paths and various types of special landscaping. For example, such "blue" streets, which control the volume and pollution of stormwater runoff in urban areas, were implemented in the cities of Portland and Seattle, the USA.

The main topic is devoted to the adaptation of the urban structure to climate change regarding new planning approaches in landscape architecture that can involve water bodies and open green spaces within cities with an already developed planning structure. The location of cities and settlements on rivers is the most common option in urban planning practice in Ukraine. This is also one of the most common cases of the location of cities in the European part of the continent because a significant number of European cities are planned and compositionally related to rivers. The problem of degradation of separate elements of river systems within cities (for example, small rivers or tides, etc.) is particularly acute. Unfortunately, this tendency has already become a characteristic of the urban planning practice of different countries.

Results and Discussion

In the course of the growing role of LA in the process of adaptation of territories and development of settlements to climatic changes, numerous new approaches and methods have been developed and their wide application has already become an essential feature of modern project practice. One such approach is represented by the method of natural and hydrological protection of coastal areas, proposed by the author, which is based on the criteria of their planning (environmental, comprehensive, integration); on the scientific basis and practical mechanisms (planning, "modeling", mathematical, organizational) of its planning approach; determined the essence of the creation of a "hybrid" system of protection and use of coastal urbanized areas, where the development of "blue-green" infrastructure is considered as an alternative basis for modern hydro technical protection of coastal areas [24]. It was established that the following are included in the planning and adaptation measures for the architectural and landscape organization of coastal and water areas: a) measures to protect and stop the water flow; b) means of passage and absorption of water currents; c) methods of water flow redistribution; d) preservation of the function of protective strips and water protection zones. When planning the relevant territories, it is envisaged to create: a) "water basins" (for water accumulation, flow regulation, territory protection); b) "residential groups" (with technical possibilities of absorption and redistribution of water); c) "water gardens" and "wetlands" (with functions of accumulation, purification, protection); d) "blue streets" (for redistribution, transportation, regulation of water flow) [22; 23; 24].


a)

b)

Fig. 3. Lybid River in the city, a tributary of the Dnipro, Kyiv. 2022. a) A plot with a natural river in the area of Lysa Hora; b) A river in a concrete collector in the Telechki industrial district [photos by author]

Furthermore, the adaptation model of the "blue-green" infrastructure can serve as a basis for developing the planning of the degraded watercourse basin to flood the riverbed and restore the river ecosystem. Therefore, this model takes into account the most difficult urban situation, when the basin of a small river is completely densely built up, which is typical, for example, for the Lybid river valley in Kyiv (Fig.3), as well as for many other cities in the world, where small rivers - tributaries of large ones - exist in a degraded state. The development of the model might require its extension and further detailed tuning to meet the specific urban LA conditions.

Each of the structural elements of the model contributes to the sustainable development of territories and ultimately the restoration of freshwater ecosystems. So far, the so-called "technical proof" of their effectiveness, which can be confirmed by hydrological calculations and, over time, by the state of the water ecosystem, is a debatable issue. In the opinion of the author, considering the development of green roof technologies and the implementation of city programs to promote their construction, we can try to predict the economic and social "effect" of the implementation of the planning model, its contribution to the preservation and restoration of freshwater ecosystems in settlements in the face of climate change and rising temperatures, which will be positive.

Green roofs are implemented around the world in various countries and regions, very often with the support of local authorities and communities. The positive experience of such a northern country as Canada shows that the special program of green roof development can provide significant economic benefits to the cities. Toronto's leadership in green roof policy began with the development of a Green Roof Strategy (2006) for the city which lays the foundation for requiring green roofs on new development in 2009. As for today, the Green Roof Bylaw (which includes a Green Roof Construction Standard) and the parallel Eco-Roof Incentive Program are responsible for over 111,400 square meters of new green space. As of 2019, approximately 620 new green roof permits have been required under the bylaw, totaling over 501,000 square meters of new green roof area [12].

Widespread implementation of green roofs in Toronto provided significant economic benefits to the city, particularly in the areas of stormwater management and reducing the urban heat island and associated energy use for cooling. Thus, green roofs retain stormwater, improve air quality, lower ambient temperatures, reduce building energy use, and create attractive and useful outdoor amenities.

The numerous advantages of green roof implementation are confirmed by the following facts. The greening of just 5 percent of the city's area through green roofs lowered the citywide temperature by an estimated 1.5° to 2°C, with a greater temperature reduction in high-density areas and with a direct 4° to 5°C roof surface cooling effect. Each year, green roofs retain 12,300 cubic meters of stormwater runoff (equivalent to 50 Olympic-sized swimming pools), reduce polluting sewer overflows to allow for three extra beach days per year, and prevent 220 metric tons of greenhouse gas emissions.

The methodological approach was presented by the author at international conferences in Turkey (2016), Spain (2016), Bulgaria (2016); Ukraine (2016, 2020); in Poland (2016, 2021).

Conclusion

In conclusion, it should be emphasized that the revealing role and significance of rivers and their riverside areas in the architectural and landscape organization of cities and other settlements are among the most topical issues in modern urban and landscape practice.

The main problems of the architectural and landscape organization of coastal and water areas, which arise as a result of natural or man-made disasters, are identified in the work (high degree of urbanization of coastal areas, the vulnerability of water ecosystems, acceleration of degradation processes of natural water bodies, the need to adapt these territories to climate change, etc,) At the same time the most urgent in the face of climate change are such issues as a) methods and ways of protecting built-up areas from floods and unforeseen heavy rain showers; b) possibilities of redistribution and use of rain-run off and other waters; c) ways of increasing the water content of the river bed in the context of climate change; d) restoration of degraded small watercourses in cities and towns, etc.

In these aspects, the adaptation model of "blue-green" infrastructure was developed by the author for a riverside city and its basic structural elements (such as water basins, residential groups, water gardens, and wet parks, "blue" streets) are identified. This model has provided planning and adaptation solutions (such as measures to protect and control the water flow; solutions for bypassing and absorbing water currents; water flow redistribution techniques, etc.). It is recommended to implement a "blue-green" infrastructure of coastal-water areas: linear (along the sea coast, large rivers, etc.), branched (at river basins with tributaries), circular (at lakes). This model has been developed as part of the method of natural and hydrological protection of urban areas.

According to providing practical recommendations for its application to urban planning practice, the following should be noted. The proposed model was developed for the conditions of the European region with a continental climate, considering the main points of the practical urban planning strategy "Sponge cities", (which was implemented in another climate). It is considered a basic one for riverside settlements for developing the planning of the degraded watercourse basin to restore the river ecosystem, with the prospect of its change, addition, and expansion in each case.

The proposed methodological approach, as well as each structural element of the model separately, have practical significance and can be used in the development of urban planning documentation at the local, regional, and state levels. The most sustainable effect can be achieved with integrated implementation, which usually occurs with the support of local authorities and the community (Canadian experience [12]).

Urban planning practices need to urgently invest in the protection and restoration of freshwater ecosystems shaped by rivers, lakes, wetlands, etc. and in this direction, the proposed adaptation model of "blue-green" urban infrastructure is very relevant. The prospect of further research may be affected by the development of similar basic models for the conditions of lakeside or seaside settlements, as well as for the option of a combined water system in the city.

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Kopsavilkums. Izstrādāta autora metodiskā pieeja, kuras pamatā ir analizēta zili-zaļās pilsētvides infrastruktūras plānošana upmalas pilsētas apstākļiem, kā viens no iespējamiem apdzīvoto vietu pielāgošanas veidiem klimata pārmaiņām. Pētījumā piedāvāts piekrastes pilsētas zili-zaļās infrastruktūras adaptīvais modelis, kā arī tā strukturālo elementu, mērķu un pielietošanas metožu tipoloģija. Konkrētā pētījumā izmantotā metodiskā pieeja rezultātā sniedz praktiskās pilsētplānošanas stratēģijas nosacījumus, kas piemērojami daudzpusīgiem klimatiskajiem apstākļiem un veiksmīgi ieviesti kopš 2000. gadiem vairākās Āzijas valstīs (Singapūra, Ķīna u. c.) un daudzās Eiropas pilsētās.