

ANNOTATION

to the dissertation submitted for the academic degree of Doctor of Philosophy (PhD) under the educational program 8D07311 - Architecture by Saya Meirkhanovna Sakenova on the topic: “Specific Features of the Development of Bioclimatic Architecture for Low-Rise Urban Housing in Southeastern Kazakhstan”

In contemporary conditions, bioclimatic architecture is considered one of the important directions of environmentally sustainable architectural design. Its significance is associated with the need to form a residential environment capable of considering the natural and climatic features of a territory, reducing building energy consumption, and ensuring comfortable living conditions.

For low-rise urban housing, this approach is of particular importance, since this type of development allows for more flexible consideration of building orientation, relief, insolation, wind regime, landscaping, and the interrelationship between architecture and the natural environment. Under the conditions of Southeastern Kazakhstan, characterized by a pronounced continental climate and significant seasonal temperature fluctuations, bioclimatic principles acquire not only environmental but also architectural and practical significance.

The present dissertation research is aimed at identifying the specific features and principles of the development of bioclimatic architecture for low-rise urban housing in Southeastern Kazakhstan, as well as substantiating differentiated architectural and planning solutions with regard to the regional natural, climatic, and urban-planning conditions.

Relevance of the study: Under conditions of global climate change, accelerated urbanization, and the increasing burden on energy systems, issues of environmental sustainability of the built environment are acquiring particular significance. Contemporary architecture and urban planning are increasingly oriented toward the principles of rational use of natural resources, energy efficiency, and the adaptation of architectural solutions to the natural and climatic conditions of territories. In this context, bioclimatic architecture is regarded as one of the effective directions of environmentally sustainable construction, ensuring reduced building energy consumption and the creation of comfortable conditions for human life and activity.

At the international level, this issue is associated with the United Nations Sustainable Development Goals for 2030, in which particular attention is given to the formation of safe, sustainable, and environmentally sustainable cities and human settlements. In the Republic of Kazakhstan, issues of environmental and energy efficiency in construction are also acquiring institutional significance. The development of the national environmental building certification system “OMIR”, the provisions of legislation on architectural, urban-planning, and construction activities, as well as the objectives of energy saving and improving energy efficiency, determine the need for the further development of green and bioclimatic construction.

This issue acquires relevance in relation to Southeastern Kazakhstan. The region is characterized by a pronounced continental climate, cold winters, a hot summer period, significant seasonal temperature fluctuations, and diverse natural landscapes. These conditions place increased demands on energy efficiency, thermal comfort, and microclimatic stability of low-rise residential development.

The design of low-rise residential buildings in this region should consider the optimization of heat loss, the rational use of solar energy, natural ventilation, building orientation, and the application of climate-adapted architectural and spatial solutions.

At the same time, existing regulatory approaches largely retain an aggregated principle of territorial regulation, under which large urban zones are considered homogeneous. Substantial microclimatic heterogeneity is observed within such zones, determined by relief, the density and morphology of development, the level of landscaping, and the characteristics of air flows.

Thus, the relevance of the present study is determined by the need for scientific substantiation of the principles for the formation of bioclimatic architecture for low-rise urban housing under the conditions of Southeastern Kazakhstan. Of particular importance is the transition from unified design solutions to a more detailed, microclimatically oriented approach aimed at increasing energy efficiency, environmental sustainability, and the comfort of the residential environment.

The object of the study is the bioclimatic architecture of low-rise urban housing, as exemplified by the cities of Almaty, Taldykorgan, and Konaev.

The subject of the study is the regularities governing the formation of architectural and planning, spatial and volumetric, and environmental solutions for low-rise urban housing, considering the natural and climatic factors of Southeastern Kazakhstan.

The aim of the study is to identify the specific features and principles of the development of bioclimatic architecture for low-rise urban housing in Southeastern Kazakhstan, taking into account regional natural, climatic, and urban-planning conditions.

Research objectives:

- 1) to conduct a theoretical analysis of the history of the emergence of bioclimatic architecture;
- 2) to examine international and domestic experience in applying the principles of bioclimatic architecture in the design of low-rise residential buildings.
- 3) to determine the factors influencing the formation of the bioclimatic architecture of low-rise urban housing in Southeastern Kazakhstan;
- 4) to identify the specific features of the architectural solution of low-rise urban housing in Southeastern Kazakhstan at the present stage;
- 5) to develop recommendations for the formation of the bioclimatic architecture of urban housing in Southeastern Kazakhstan.

State of research on the topic

The issues of bioclimatic architecture and climate-adapted design of the residential environment have been widely developed in domestic and international scholarly literature. Contemporary studies address questions concerning the interaction between architecture and natural and climatic factors, the formation of an energy-efficient residential environment, and the development of principles of sustainable architectural design.

The theoretical foundations of bioclimatic architecture were formed in the works of international researchers. A significant contribution to the development of climate-adaptive architecture was made by the studies of V. Olgyay [6], in which the foundations of climate-oriented design were developed, and the bioclimatic chart was proposed as a tool for analyzing comfortable climatic conditions. The works of Luis de Garrido [7], Willi Weber and Simos Yannas [8], Norbert Lechner [9], Ken Yeang [10–14], Richard Saxon [15], and Richard Hyde [16] address issues of environmentally sustainable architecture, passive strategies of climatic adaptation, building energy efficiency, and the integration of the natural environment into architectural solutions.

The problems of the influence of natural and climatic conditions on the formation of the architecture of residential buildings have a long scholarly tradition. The foundations of climatically conditioned design can be traced in the works of M. Vitruvius [17], L. B. Alberti [20], A. Palladio [20], and Auguste Choisy [19], and in

the twentieth century were further developed in the works of Le Corbusier [21–24] and F. L. Wright [25–28], where issues of the interrelationship between architectural form, landscape, and the natural environment were examined.

In domestic architectural scholarship, issues concerning the influence of natural and climatic factors on architectural design were developed in the studies of B. G. Barkhin [29], D. A. Kemenov [30], S. Giedion [30], J. E. Aronin [31], V. K. Litskevich [32–33], T. B. Rapoport [36–38], T. K. Basenov [39], M. M. Mendikulov [43], B. A. Glaudinov [42], B. U. Kuspangaliyev [43], A. T. Akhmedova [44], A. Zh. Abilov [45], E. K. Dyusebay [46], K. Samoilov [47], G. S. Abdrasilova [48], G. K. Sadvokasova [49], A. A. Kornilova [50], S. E. Mamedov [51], M. V. Reva [52], and L. E. Mamedova and A. Zh. Abilov [53]. These studies examine issues of forming an architectural environment regarding natural and climatic conditions, the urban-planning development of territories, the typology of residential buildings, and architectural and planning solutions.

Despite the considerable body of research devoted to sustainable architecture and the climatic adaptation of buildings, the problems of forming the bioclimatic architecture of low-rise urban housing under the conditions of Southeastern Kazakhstan remain insufficiently studied. Existing works focus mainly either on general issues of sustainable architectural design or on individual aspects of the climatic adaptation of buildings, whereas a comprehensive study of the architectural principles for the formation of bioclimatic low-rise housing, considering regional natural and climatic as well as urban-planning factors, remains underrepresented.

In this regard, there is a need for a comprehensive scientific study aimed at identifying the principles for the formation of bioclimatic architecture for low-rise urban housing under the conditions of the Southeastern region of Kazakhstan.

The scientific hypothesis of the study consists in the assumption that the bioclimatic architecture of low-rise urban housing may be regarded as an effective model for the formation of a sustainable residential environment, ensuring comfortable living conditions through the integration of natural and climatic factors, architectural and planning solutions, and environmentally oriented design principles. Considering the microclimatic heterogeneity of urban territory and differentiating architectural and planning solutions depending on the site type make it possible to increase the effectiveness of bioclimatic design and ensure a more precise adaptation of low-rise residential development to local environmental conditions.

Thus, bioclimatic architecture is regarded not only as a technological approach, but also as an architectural-environmental approach to the formation of the residential environment, oriented toward sustainable urban development.

Research methods: the methodological foundation of the study was constituted by a set of interrelated scientific methods aimed at identifying the principles for the formation of the bioclimatic architecture of low-rise urban housing.

The following methods were used in the study:

- 1) theoretical analysis of scholarly literature - analysis of domestic and international studies on issues of bioclimatic architecture, sustainable architectural design, and the climatic adaptation of buildings;

- 2) comparative-typological analysis of architectural solutions - comparative analysis of low-rise housing projects under various climatic conditions, including international experience and design practice in Kazakhstan;

- 3) analysis of the region's natural and climatic factors - study of temperature regimes, solar radiation, wind conditions, and humidity indicators influencing architectural solutions for low-rise housing;

- 4) bioclimatic analysis and comparative climatic interpretation - assessment of climatic comfort and substantiation of preliminary architectural design strategies

through the combined interpretation of climatic indicators. Within this framework, the Olgyay bioclimatic chart was considered as a theoretical and methodological reference for climate-oriented design, while the Mahoney climate tables were used as a simplified comparative tool for deriving preliminary architectural recommendations for the cities of Almaty, Konaev, and Taldykorgan;

5) graphic-analytical method - analysis of architectural and spatial solutions for low-rise housing and identification of the regularities governing the formation of bioclimatic architecture;

6) method of architectural synthesis - formulation of recommendations for the formation of the bioclimatic architecture of low-rise urban housing in Southeastern Kazakhstan on the basis of the results of theoretical and climatic analysis.

The boundaries of the study are defined by the examination of the problems involved in the formation of the architectural and planning structure of bioclimatic low-rise urban housing under the conditions of Southeastern Kazakhstan.

The territorial boundaries of the study encompass the cities of Almaty, Konaev, and Taldykorgan, which are characterized by similar natural and climatic conditions and specific features of urban-planning development.

The architectural boundaries of the study include an analysis of the functional, spatial and volumetric, and architectural-compositional principles of the formation of low-rise urban housing, considering bioclimatic factors and the specific features of the region's natural environment.

The reliability of the scientific results of the dissertation research is ensured by a set of complementary methods: analysis of scholarly literature, comparative-typological analysis of architectural solutions, and interpretation of the region's natural and climatic conditions. The study is based on climatic data for the territories under investigation, an analysis of the architectural practice of low-rise housing construction, and a comparative interpretation of regional climatic indicators. The interpretation of climatic data, supported by theoretical reference to the Olgyay bioclimatic chart and the simplified comparative use of Mahoney climate tables, enabled the identification of regularities in the formation of architectural solutions adapted to the natural and climatic conditions of Southeastern Kazakhstan. The comprehensive nature of the study confirms the scientific substantiation of the conclusions and recommendations obtained.

The results obtained have not only a descriptive but also an analytical and design-oriented character, since they link the natural and climatic characteristics of the territory with specific architectural and planning solutions. In the study, the microclimatic heterogeneity of the urban environment is considered as a key criterion for the transition from aggregated territorial zoning to differentiated design. This approach makes it possible to clarify the applicability of bioclimatic principles to the conditions of Almaty, Konaev, and Taldykorgan and to form a basis for the typological classification of microclimatic zones. As a result, a logical connection is established between climatic analysis, territorial classification, and recommendations for the formation of energy-efficient and comfortable low-rise urban housing.

The scientific novelty of the study lies in the development of architectural principles for the formation of the bioclimatic architecture of low-rise urban housing as applied to the natural and climatic conditions of Southeastern Kazakhstan.

In the dissertation:

1) for the first time, a comprehensive study has been carried out of the architectural principles for the formation of the bioclimatic architecture of low-rise urban housing in Southeastern Kazakhstan, considering multilevel climatic analysis - macro-, meso-, and microclimate.

2) natural and climatic, and urban-planning factors influencing architectural and planning solutions for low-rise housing have been identified and systematized, including relief, the morphology of development, and the aeration regime of the territory;

3) the necessity of differentiating architectural and planning solutions for low-rise development depending on local microclimatic conditions has been theoretically substantiated.

4) based on an analysis of the natural and climatic, morphological, and urban-planning characteristics of Almaty, Taldykorgan, and Konaev, the regularities of the microclimatic heterogeneity of the urban environment have been identified, and their theoretical-cartographic generalization has been carried out;

5) a theoretical classification of territory types - microclimatic zones - has been formed for the cities of Almaty, Taldykorgan, and Konaev;

6) the author's model for the formation of the bioclimatic architecture of low-rise housing has been developed, reflecting the interrelationship among natural and climatic, urban-planning, and architectural and planning factors and ensuring the differentiation of design solutions by types of microclimatic zones.

Main provisions submitted for defense:

1) bioclimatic architecture is an effective approach to the formation of low-rise urban housing, ensuring increased building energy efficiency and improved microclimatic comfort of the residential environment under the continental climate of Southeastern Kazakhstan;

2) the formation of architectural and planning solutions for low-rise housing is determined by a combination of natural and climatic as well as urban-planning factors, including temperature regime, solar radiation, wind conditions, humidity characteristics, the morphology of development, territorial relief, and the microclimatic heterogeneity of the urban environment;

3) the microclimatic heterogeneity of urban territory determines the need to shift from aggregated urban-planning zoning to differentiated design of low-rise residential development with regard to local site conditions;

4) the microclimatic heterogeneity of the urban environment is a key factor in shaping the bioclimatic architecture of low-rise housing and requires a transition from aggregated urban-planning zoning to differentiated design;

5) the classification of territories by microclimatic characteristics constitutes the basis for the formation of differentiated design solutions for low-rise residential development in the cities of Almaty, Taldykorgan, and Konaev;

6) the combined interpretation of climatic data, with reference to the Olgyay bioclimatic chart and the simplified comparative use of Mahoney climate tables, together with the analysis of development morphology and the generalization of microclimatic conditions, makes it possible to substantiate the choice of architectural and planning solutions for different types of territories;

7) the author's theoretical model for the formation of bioclimatic architecture provides a systemic representation of the interrelationship among natural and climatic, urban-planning, and architectural factors and serves as a basis for the differentiation of design solutions.

The scientific and theoretical significance of the study lies in the development of the theoretical and methodological foundations of bioclimatic architecture as applied

to the conditions of Southeastern Kazakhstan. The results obtained expand scholarly understanding of the regularities of interaction between architectural solutions and natural and climatic factors in the formation of a low-rise residential environment and also supplement the theoretical basis of research in sustainable architectural design and environmentally oriented development of the urban environment.

The practical significance of the study lies in the development of architectural recommendations for the formation of low-rise urban housing with regard to the bioclimatic conditions of the Southeastern region of Kazakhstan.

The results of the study may be used:

- in architectural design practice when developing low-rise housing projects;
- in the development of regional building codes and recommendations in the field of sustainable and energy-efficient construction;
- in the educational process for training specialists in architecture, urban planning, and environmentally oriented design.

The author's personal contribution lies in conducting a comprehensive study of the specific features of the formation of bioclimatic architecture for low-rise urban housing under the conditions of Southeastern Kazakhstan. The author analyzed architectural and planning solutions for low-rise housing and courtyard spaces and identified the influence of building orientation, the organization of courtyard areas, and architectural-spatial solutions on the formation of a favorable microclimate in the residential environment.

Based on the results of the study, recommendations were formulated for the design of low-rise urban housing with regard to the key factors of the natural environment:

- 1) regarding the minimum and maximum temperatures of the region, architectural solutions were proposed to prevent overheating and overcooling of buildings;
- 2) regarding the wind regime of the region, the need to form solutions ensuring natural ventilation and a favorable air-exchange regime was substantiated;
- 3) regarding the orientation of buildings in relation to the cardinal directions, recommendations were proposed for the spatial organization of residential development aimed at increasing energy efficiency and improving microclimatic conditions;
- 4) particular attention was given to the formation of an environmentally safe residential environment, including the selection of building materials, architectural and planning solutions, and engineering systems.

Approbation of the main provisions

The scientific results and provisions of the dissertation were discussed at a meeting of the methodological seminar of the School of Architecture of the International Educational Corporation. The main provisions, results, and conclusions of the dissertation research were presented in scholarly publications and in the proceedings of international scientific and practical conferences.

The results of the dissertation research were published in 6 (six) scientific works by the author, reflecting the main conclusions of the study. These include:

- 2 articles in international peer-reviewed scholarly journals indexed in the Scopus database;
- 1 article in a publication recommended by the Committee for Quality Assurance in Science and Higher Education of the Republic of Kazakhstan;
- 3 publications in proceedings of international scientific and practical conferences.

MAIN CONTENT OF THE WORK

The dissertation is devoted to the study of the specific features of the formation of bioclimatic architecture for low-rise urban housing under the conditions of Southeastern Kazakhstan. The work examines the theoretical foundations of bioclimatic architecture, principles of climate-oriented design, international and domestic experience, contemporary factors in the formation of bioclimatic architecture, as well as architectural and planning, spatial and volumetric, and environmental solutions for low-rise urban housing.

The introduction presents the relevance of the topic, which is determined by global climate change, urbanization, the increasing burden on energy systems, and the need to adapt architectural solutions to the natural and climatic conditions of territories. The significance of bioclimatic architecture as a direction of environmentally sustainable construction aimed at reducing building energy consumption and creating comfortable conditions for human life and activity is substantiated.

The introduction also defines the state of research on the topic, the scientific hypothesis, the aim and objectives, the object and subject, the methods and boundaries of the study, the reliability of the scientific results, the scientific novelty, the main provisions submitted for defense, the significance of the study, the author's personal contribution, approbation of the results, and the volume and structure of the dissertation.

The first section examines the theoretical foundations of bioclimatic architecture design for low-rise housing: the history of its formation, international experience in the design of low-rise residential buildings considering bioclimatic conditions, as well as the influence of natural and climatic factors on the architecture of low-rise residential buildings in Kazakhstan.

Bioclimatic architecture is considered as a scholarly direction associated with the consideration of climatic and ecological conditions of regions in architectural design. Attention is given to the works of G. H. Olgyay, in which the theoretical foundation for designing buildings regarding climatic conditions was formed and a methodology for integrating climatic parameters into architectural design was developed.

The international experience examined showed that bioclimatic design in international practice is developing as a systemic approach that integrates architectural and planning, structural, engineering, and environmental solutions. Their effectiveness is determined by their comprehensive application regarding climate, landscape, and the character of development.

The influence of natural and climatic factors on the architecture of low-rise residential buildings in Kazakhstan was considered separately. It was established that the climatic conditions of the country have a determining influence on the formation of housing architecture and require the development of adaptive design solutions aimed at ensuring a comfortable microclimate.

Conclusions to Section One

1. The theoretical analysis carried out showed that bioclimatic architecture was formed because of the evolution of architectural and construction practices oriented toward the adaptation of buildings to natural and climatic conditions. It was established that its origins go back to traditional types of vernacular housing, where passive methods of microclimate regulation were used: orientation in relation to the cardinal directions, the use of the thermal inertia of materials, and natural ventilation.

2. It was revealed that in the twentieth and twenty-first centuries, bioclimatic architecture received scientific substantiation and development through the introduction of engineering calculations, energy modeling, and the principles of

sustainable development. The contemporary stage is characterized by the integration of digital technologies, including BIM and climate modeling, which ensures increased energy efficiency and environmental sustainability of buildings.

3. The analysis of international experience showed that in countries with different climatic conditions (Europe, the Middle East, Asia), the principles of bioclimatic design are actively applied, including the use of solar energy, adaptive facades, green roofs, and natural cooling systems. These solutions demonstrate high effectiveness in reducing energy consumption and improving living comfort.

4. The study of domestic experience revealed that in Kazakhstan, elements of bioclimatic architecture are applied fragmentarily and most often at the level of individual design solutions: building orientation, insulation, and the use of local materials. However, a comprehensive approach to bioclimatic design is still at the stage of formation.

5. It was established that the main limiting factors in the implementation of bioclimatic principles in domestic practice are an insufficient regulatory and methodological base, limited use of digital tools for climatic analysis, and insufficient integration of interdisciplinary approaches in design.

6. Overall, the results of the first section confirm the need to develop an adapted model of bioclimatic design for low-rise residential buildings regarding the climatic, socio-economic, and technological conditions of the Republic of Kazakhstan.

The second section examines contemporary factors influencing the formation of the bioclimatic architecture of low-rise urban housing in Southeastern Kazakhstan: international and national certification systems for sustainable construction, concepts of sustainable development in low-rise construction, socio-economic and demographic features of the region's cities, and the natural and climatic as well as urban-planning conditions for the formation of the residential environment.

Contemporary trends in the design of energy-efficient and environmentally oriented buildings were examined, including reducing energy consumption, minimizing environmental impact, rational use of natural resources, implementation of energy-saving technologies, and adaptation of buildings to local climatic conditions.

Sustainable construction certification systems - LEED, BREEAM, DGNB, and WELL - were analyzed as systems forming criteria for assessing the energy efficiency, environmental performance, and comfort of buildings. It is noted that their application requires considering regional natural and climatic, urban-planning, and socio-economic features.

The section also examines contemporary concepts of sustainable development in low-rise construction, based on an integrated approach to design, the use of renewable energy sources, environmentally safe materials, principles of the circular economy, and low-carbon development.

The socio-economic and demographic features of Almaty, Konaev, and Taldykorgan were analyzed, including the modernization of the urban environment, urban population growth, changing housing needs, and increasing requirements for the quality of the residential environment.

Attention was given to natural and climatic as well as urban-planning factors: temperature regime, solar radiation, wind conditions, humidity indicators, relief, development density, block orientation, configuration of the street and road network, and landscaping.

It was established that these factors affect the residential environment unevenly, forming areas within urban territory that differ in bioclimatic characteristics. This confirms the need to consider the microclimatic heterogeneity of the urban structure when designing low-rise housing.

Conclusions to Section Two

1. It was established that the formation of the bioclimatic architecture of low-rise urban housing in Southeastern Kazakhstan is determined by a set of interrelated factors: natural and climatic, urban-planning, socio-economic, and technological. Their comprehensive consideration is a necessary condition for ensuring energy efficiency, environmental sustainability, and comfort of the residential environment.

2. The analysis of the region's natural and climatic conditions (a sharply continental climate, significant daily and seasonal temperature fluctuations, high solar insolation, and wind loads) showed that the key bioclimatic design parameters are building orientation, protection against overheating in summer, heat retention in winter, and the use of natural ventilation and insolation.

3. It was revealed that urban-planning factors (development density, block orientation, the configuration of the street and road network, and the presence of landscaped spaces) substantially influence the formation of the local microclimate and the energy balance of residential territories. Rational organization of the urban structure contributes to reducing heat loss and improving the environmental characteristics of the environment.

4. It was established that contemporary international and national certification systems for sustainable construction (LEED, BREEAM, DGNB, and WELL) form universal criteria for assessing the energy efficiency, environmental performance, and comfort of buildings; however, their direct application requires adaptation to the specific climatic and socio-economic conditions of Kazakhstan.

5. The analysis of contemporary concepts of sustainable development in low-rise construction showed that the priority directions are energy efficiency, the use of renewable energy sources, the application of environmentally safe materials, and the implementation of the principles of the circular economy and low-carbon development.

6. The study of the socio-economic and demographic features of the region revealed steady urban population growth, increasing demand for affordable and comfortable housing, and the need to optimize construction and building operation costs. This determines the demand for bioclimatic solutions as economically effective and sustainable in the long term.

7. It was established that the contemporary development of digital technologies, such as climate modeling, BIM, and digital twins, opens new opportunities for the comprehensive analysis of factors and the optimization of design solutions in bioclimatic architecture, ensuring greater accuracy of forecasting and design effectiveness.

8. As a result of the analysis, a system of key factors influencing the formation of the bioclimatic architecture of low-rise urban housing in Southeastern Kazakhstan was determined, creating a scientific basis for the development of an adapted design model that considers regional features and contemporary requirements of sustainable development.

The third section examines the bioclimatic architecture of low-rise urban housing in Southeastern Kazakhstan: architectural and planning and spatial and volumetric solutions, the placement of low-rise residential buildings within the urban system, and recommendations for the formation of a bioclimatic residential environment.

It was established that the formation of low-rise urban housing must consider natural and climatic, urban-planning, socio-economic, and architectural and planning factors. Of particular importance are building orientation, insolation, wind regime, relief, development density, organization of courtyard spaces, and the interrelationship between residential development and the natural environment.

Solutions aimed at ensuring a comfortable, energy-efficient, and

environmentally sustainable residential environment were examined: compact and adaptive planning structures, functional zoning, buffer spaces, shading devices, green spaces, usable roofs, and other elements of passive architecture.

It was substantiated that the placement of low-rise residential buildings within the urban system should be carried out regarding local natural and climatic conditions, the microclimatic heterogeneity of the urban environment, relief, insolation, and wind regime. This makes it possible to move from unified design solutions to a differentiated approach in the formation of low-rise residential development.

A classification of territory types - microclimatic zones - and developed the author's model for the formation of bioclimatic architecture, ensuring the differentiation of architectural and planning solutions depending on microclimatic conditions.

Conclusions to Section Three

1. It was established that the bioclimatic architecture of low-rise urban housing in Southeastern Kazakhstan is formed as a comprehensive system based on the integration of natural and climatic, urban-planning, and architectural and planning factors, which ensures the creation of an energy-efficient, environmentally sustainable, and comfortable residential environment.

2. The analysis of architectural and planning solutions showed that the most effective are compact and adaptive planning structures oriented in relation to the cardinal directions, with functional zoning that ensures maximum use of solar energy in winter and protection against overheating in summer.

3. It was revealed that the specific features of spatial and volumetric solutions for low-rise housing consist in forming optimal building proportions, using buffer spaces (vestibules, terraces, galleries, as well as elements of passive architecture), shading devices, green spaces, and usable roofs that contribute to improving the microclimate.

4. It was established that the placement of low-rise housing within the urban system should consider the principles of bioclimatic zoning, the wind rose, insolation, and the specific features of relief. Rational integration of residential development into the urban structure contributes to the formation of a favorable microclimate and to improving the quality of the urban environment.

5. It was demonstrated that low-rise urban housing is a promising direction for the development of the contemporary urban environment, ensuring a balance between development density, living comfort, and environmental sustainability, particularly under the conditions of Southeastern Kazakhstan.

6. The key role of the interrelationship between low-rise residential buildings and the natural environment was established, expressed in the integration of green spaces, the use of natural landscape features, and the formation of environmentally balanced residential territories.

7. Recommendations were developed for the formation of the bioclimatic architecture of low-rise urban housing in Southeastern Kazakhstan, including building orientation with regard to insolation and wind regime, the application of energy-efficient structural and spatial-planning solutions, the use of local and environmentally friendly building materials, the integration of green infrastructure, consideration of microclimatic zones in residential development design, and the implementation of principles of sustainable development and low-carbon construction.

8. It was scientifically substantiated that the proposed recommendations ensure increased energy efficiency, reduced operating costs, and improved environmental characteristics of the residential environment, which confirms their practical significance.

9. The key result of the study is the development of the author's model for the formation of the bioclimatic architecture of low-rise housing, reflecting the

interrelationship among natural and climatic, urban-planning, and architectural and planning factors and ensuring the differentiation of design solutions depending on the type of microclimatic zone, which makes it possible to adapt architectural solutions to the regional conditions of Southeastern Kazakhstan.

10. Overall, the results of the third section form a scientific and practical basis for implementing bioclimatic principles in the design of low-rise urban housing and may be used in the development of regulatory documents, architectural projects, and strategies for the sustainable development of the region's cities.

CONCLUSION

The conclusion summarizes the results of the three sections of the dissertation research and notes that the research hypothesis has been confirmed. In the course of the work carried out, it was substantiated that the bioclimatic architecture of low-rise urban housing may be regarded as an effective model for the formation of a sustainable residential environment, ensuring comfortable living conditions through the comprehensive integration of natural and climatic factors, architectural and planning solutions, and environmentally oriented design principles.

The main results of the study are as follows:

1. The theoretical analysis carried out showed that bioclimatic architecture was formed because of the evolution of architectural and construction practices oriented toward the adaptation of buildings to natural and climatic conditions. It was established that its origins go back to traditional types of vernacular housing, where passive methods of microclimate regulation were used.

2. It was established that the formation of the bioclimatic architecture of low-rise urban housing in Southeastern Kazakhstan is determined by a set of natural and climatic, urban-planning, socio-economic, technological, and architectural and planning factors. Their comprehensive consideration is a necessary condition for ensuring energy efficiency, environmental sustainability, and comfort of the residential environment.

3. It was substantiated that considering the microclimatic heterogeneity of urban territory and differentiating design solutions depending on site characteristics make it possible to increase the effectiveness of the bioclimatic approach and ensure a more precise adaptation of residential development to local environmental conditions.

4. It was revealed that the formation of low-rise urban housing must consider relief, insolation, wind regime, development density, landscaping, the character of urban morphology, and the thermal balance of the environment. This confirms the need to move from unified design solutions to differentiated design.

5. Recommendations were developed for the formation of the bioclimatic architecture of low-rise urban housing in Southeastern Kazakhstan, including building orientation with regard to insolation and wind regime, the application of energy-efficient structural and spatial-planning solutions, the use of local and environmentally friendly building materials, the integration of green infrastructure, consideration of microclimatic zones in residential development design, and the implementation of principles of sustainable development and low-carbon construction.

6. The key result of the study is the development of the author's model for the formation of the bioclimatic architecture of low-rise housing, reflecting the interrelationship among natural and climatic, urban-planning, and architectural and planning factors and ensuring the differentiation of design solutions depending on the type of microclimatic zone.

7. The results obtained form a scientific and practical basis for implementing bioclimatic principles in the design of low-rise urban housing and may be used in the

development of regulatory documents, architectural projects, and strategies for the sustainable development of the region's cities.

The following publications have been prepared on the topic of the dissertation research:

1. *Conformation Factors of Building Bioclimatic Microclimate*, Civil Engineering and Architecture, 12(1): 350–360, 2024. Publisher: Horizon Research Publishing. ISSN: 2332-1091. DOI: 10.13189/cea.2024.120126. Cite Score - 1.4, percentile - 66.

2. *Стратегии развития архитектуры жилых зданий Казахстана*, Visual Arts and Performing Arts, Project Baikal, No. 87: 38–43, 2026. ISSN: 2307-4485. E-ISSN: 2309-3072. Cite Score - 0.4, percentile - 32.

3. *Bioclimatic architectural and compositional approaches to residential design in the urban environment*, 19th International Scientific and Practical Internet Conference “Problems and Prospects for the Development of Modern Science in European and Asian Countries”. Pereiaslav, Ukraine, 2025. pp. 44–47.

4. *The potential of smart technologies in the development of sustainable bioclimatic housing*, 19th International Scientific and Practical Internet Conference “Problems and Prospects for the Development of Modern Science in European and Asian Countries”. Pereiaslav, Ukraine, 2025. pp. 47–50.

5. *Эволюция пространственной структуры города Алматы под воздействием квартальной и точечной застройки*, 19th International Scientific and Practical Internet Conference “Problems and Prospects for the Development of Modern Science in European and Asian Countries”. Pereiaslav, Ukraine, 2025. pp. 50–53.

6. *Microclimatic differentiation of low-rise housing in Southeastern Kazakhstan*, *QazBSQA Bulletin*, No. 2 (100), 2026. *Architecture*. C. 8-19. DOI:10.51488/1680-080X/2026.2-01

Volume and structure of the dissertation.

The dissertation consists of an introduction, three sections, a conclusion, a list of references, and appendices.

The first section examines the theoretical foundations of bioclimatic architecture and the principles of climate-oriented design, and analyzes international and domestic experience in shaping the residential environment.

The second section analyzes the natural and climatic conditions of the Southeastern region of Kazakhstan and the factors influencing the formation of architectural solutions for low-rise housing. A bioclimatic analysis of the cities of Almaty, Konaev, and Taldykorgan was conducted, the microclimatic heterogeneity of the urban territory was identified, and the need to differentiate design solutions was substantiated.

The third section presents a classification of territory types (microclimatic zones) and develops the author's model for the formation of bioclimatic architecture, ensuring differentiation in architectural and planning solutions based on microclimatic conditions.

The internal logic of the dissertation is based on a gradual transition from theoretical and historical analysis to the identification of regional factors, and then to the development of differentiated architectural recommendations.

The dissertation comprises 144 numbered pages before the appendices. The list of references includes 197 titles. The appendices comprise 42 pages.