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# SOCIO-TECHNICAL REQUIREMENTS FOR HOUSING AND INFRASTRUCTURE IN THE GAS-PRODUCING REGIONS OF UZBEKISTAN: A COMPARATIVE ANALYSIS OF THE REPUBLIC OF KARAKALPAKSTAN AND THE BUKHARA REGION

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**Abstract**

This paper ascertains and organizes the prerequisites for dwellings and supporting systems in the gas-producing areas of Uzbekistan, employing the Republic of Karakalpakstan and the Bukhara Region as examples. The importance of this research stems from the fact that the gas sector's growth in dry territories characterized by considerable ecological and engineering fragility necessitates not only industrial advancement but also a core rethinking of housing and necessary facilities. The research seeks to formulate a comprehensive socio-technical blueprint of planning and administration norms for the living environment, transit, public services, power, and digital networks amidst intense warmth, water shortage, saline dust exposure, seismic activity, and scattered population centers. The research methodology merges contrasting regional assessment, the examination of technical and governing papers, the understanding of global analytical data, and the combination of methods for structuring permanent and temporary lodging in resource-extraction zones. The outcomes demonstrate that prosperous advancement of gas-producing locales is unachievable without merging residential building with water provision, thermal supply, transportation reachability, healthcare and communal support, and digital linkage. The study supports the necessity for self-contained thermal supply setups, improved thermal shielding, air purification, modular designs for distant locations, alongside monitoring-driven planning and inter-sectoral administration. The utility of the article rests in the potential to employ the suggested framework in local initiatives, urban planning choices, and technical summaries for gas-producing territories.

**Keywords**

gas-producing regions; Republic of Karakalpakstan; Bukhara Region; housing; engineering infrastructure; arid territories; energy efficiency; rotational worker settlements; climate resilience.

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**Introduction**

The reshaping of Uzbekistan's energy sector is a primary impetus for the nation's regional advancement. Within the national economy's framework, the gas industry represents a significant portion of the industrial focus for the western and central areas and establishes fresh demands for settlement formats, workforce movement, and the standard of the living space [6; 9].

In this setting, the Republic of Karakalpakstan and the Bukhara Region hold special investigative significance. On one side, these territories host vital areas for gas recovery and hydrocarbon refinement; on the other, they exhibit a blend of a dry climate, limited freshwater availability, significant ecological sensitivity, and geotechnical limitations. For Karakalpakstan, an extra destabilizing element stems from the shrinking of the Aral Sea, while in the Bukhara Region, industrial strain converges with water management limitations and challenging ground conditions [10-12].

The issue is that expansion in the extractive field is typically evaluated via output figures, whereas amenities and infrastructure are viewed as lesser priorities. Nevertheless, given remote industrial locations, elevated atmospheric warmth, saline-dust squalls, and the necessity to draw skilled workers, the caliber of lodging and amenities transforms into a component of operational stability instead of purely a matter of social planning.

This paper intends to pinpoint and organize the socio-technical prerequisites for housing and infrastructure in Uzbekistan's gas-producing zones through a joint examination of the Republic of Karakalpakstan and the Bukhara Region. To meet this goal, the research tackles four aims: (1) to specify the natural-climatic and population preconditions; (2) to ascertain the governing, physical, and functional needs for dwellings; (3) to categorize the demands for transport, utility, power, and digital networks; and (4) to evaluate the suitability of global practice for Uzbekistan's circumstances.

**Materials and Methods**

The aim of this research is Uzbekistan's gas-producing areas, while the focus is the collection of residential and infrastructural necessities that guarantee their stable operation amid difficult natural-climatic and socio-spatial circumstances.

The empirical and analytical foundation of the research includes: (a) regulatory documents of the Republic of Uzbekistan in the areas of city planning, water provision, thermal supply, and planning in tremor zones; (b) global analytical summaries concerning urbanization, climate hazards, water networks, and transit facilities; (c) writings dedicated to the progress of the gas sector and the

arrangement of dwellings in extraction regions; and (d) the user-supplied English analytical piece containing structured figures regarding Karakalpakstan and the Bukhara Province.

The research utilizes the subsequent techniques: contrasting regional examination, document scrutiny and rule comprehension, specific project examination of fixed and rotational living arrangements, and structural combination.

A constraint of the research is the lack of field assessments of the local climate, physical inspections of the dwelling units, and societal figures regarding the contentment of occupants and laborers. Due to this, the paper is diagnostic and theoretical in character and is directed mainly toward the design-regulatory articulation of the issue.

**Results**

The results are presented along five interrelated dimensions: territorial-demographic preconditions, natural-climatic and engineering-geological constraints, requirements for permanent housing, requirements for shift settlements, and requirements for basic infrastructure.

The spatial localization of the study areas determines differences in their risk profiles and in the configuration of infrastructural provision. The Republic of Karakalpakstan occupies a vast, sparsely populated, and environmentally stressed territory, whereas the Bukhara Region is characterized by a more compact settlement pattern and a stronger connection to the production and transport nodes of the country's central part (Fig. 1).

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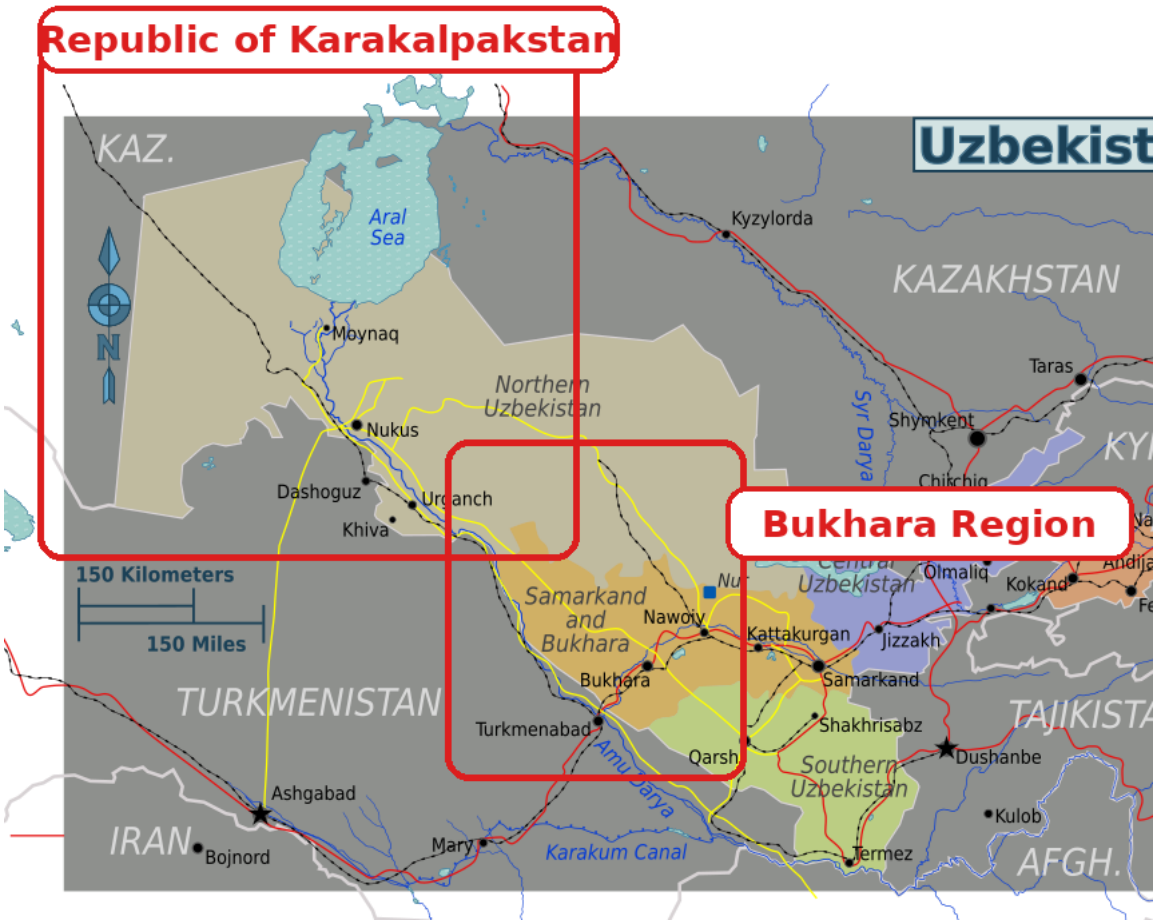


*Figure 1. Spatial location of the study regions within the regional structure of Uzbekistan*

Source: adapted by the author from the materials of the UN Cartographic Section / Wikimedia Commons [13].

On the basis of the source comparison, the core characteristics determining the design requirements for housing and infrastructure were identified (Table 1).

*Table 1. Comparative characteristics of the study regions*

| Indicator | Republic of Karakalpakstan | Bukhara Region | Design implication |
|---|---|---|---|
| Population density (according to the source review) | approx. 8 persons/km² | approx. 62 persons/km² | Karakalpakstan requires a more dispersed service network and greater settlement autonomy; the Bukhara Region requires stronger integration with urban nodes. |
| Climate type | arid/desert | semi-arid to desert | Enhanced thermal protection, overheating control, and protection against dust and salt exposure are required. |
| Environmental pressure | very high; impact of the | high; water scarcity and | Air filtration, water conservation, and durable external envelopes |

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|---|---|---|---|
| | Aral crisis | heat stress | are required. |
| Key specialization | gas extraction in the Ustyurt zone | gas extraction, processing, and petrochemistry | Housing and infrastructure must serve both the permanent population and a mobile workforce. |
| Engineering constraints | remoteness, water scarcity, salt-dust loads | subsiding soils, water scarcity, temperature fluctuations | Adapted foundations, reliable networks, and redundancy of critical systems are required. |

Source: compiled by the author from materials [2; 6; 10-12].

The initial set of outcomes pertains to natural-climatic and engineering-geological limitations. The drying of the Aral Sea resulted in the creation of a sizable salt-dust dispersal area, which heightens the abrasive effect on facade components, window setups, ventilation apparatus, and exterior service networks [10-12]. For building practice, this implies that standard designs suitable in mild climates result here in quickened degradation of structure exteriors and greater operational expenditures.

A further limitation is the considerable seasonal and daily temperature variation. In the examined areas, the thermal resilience of the living space is dictated not just by compliant insulation, but also by the necessity to lessen indoor overheating during the warmer months. Therefore, multi-layered envelopes, solar shielding, judicious placement relative to the cardinal points, and effective air-exchange mechanisms are truly vital for residential and civic structures.

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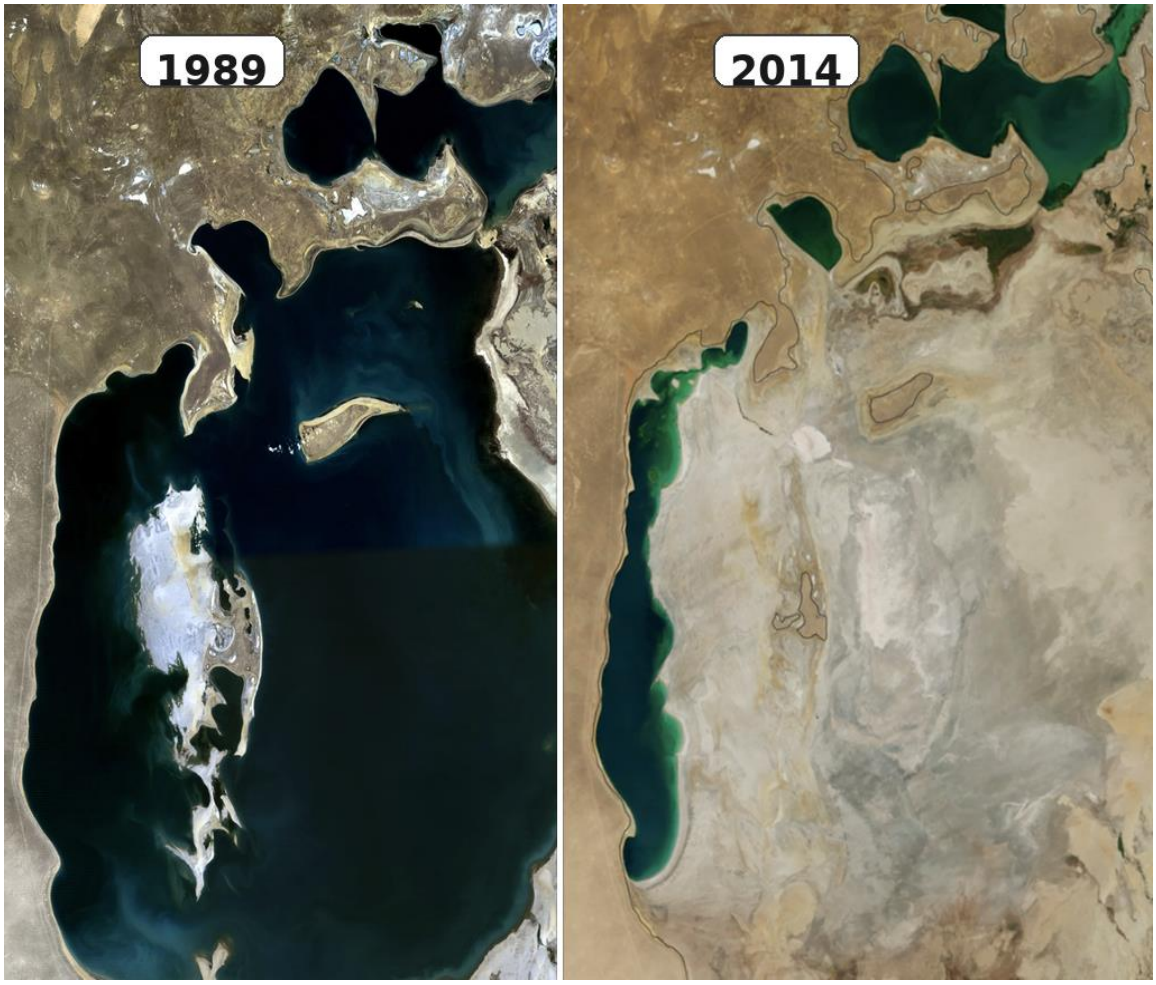


*Figure 2. Comparison of the state of the Aral Sea in 1989 and 2014*

Source: NASA / Wikimedia Commons [14].

The subsequent section of findings demonstrates that the geotechnical circumstances necessitate a varied strategy. For zones prone to earthquake activity and loess terrains, the Uzbek building standards regulating structural assessment in seismic areas and design on sinking ground are especially vital [4; 7]. In dry climates, though, even minor escapes from water distribution systems can notably change the state of the underlying soil, making the dependability of subterranean infrastructure a structural security concern rather than just operational ease.

The final segment of results pertains to the mandates for long-term residences. The review reveals that in districts producing natural gas, merely boosting the quantity of housing creation is inadequate; a housing expansion approach is required where dwellings are viewed as an element of a holistic urbanized grouping. This suggests easily reachable basic amenities, transit linkage, setting aside utility capacity, and integrating schooling, medical care, and daily provision centers within the framework of fresh residential zones. [2; 9].

The key design requirements for residential development are summarized in Table 2.

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*Table 2. Systematization of housing requirements in gas-producing regions*

| Requirement group | Criterion | Design implication | Regulatory/analytical basis |
|---|---|---|---|
| **Spatial planning** | At least 16 m² of living area per person; flexible layout options | A shift from minimally acceptable housing toward flexible typologies for family households and rotational personnel | [4] |
| **Thermal engineering** | High thermal protection, overheating control, controlled air exchange | Greater importance of the building envelope, shading devices, and energy-efficient ventilation systems | [7; 12] |
| **Engineering systems** | Closed-loop heat supply systems; metering; water reserve capacity | Reduced water and heat losses; increased resilience to accidents and resource shortages | [7; 8] |
| **Sanitary and hygienic** | Air filtration; protection against dust and salts | Need for a higher tightness class of windows, doors, and ventilation systems | [10-12] |
| **Social** | Accessibility for persons with limited mobility; availability of social infrastructure | Integration of housing with healthcare, education, and service facilities | [2; 9] |
| **Safety** | Gas monitoring, fire safety, seismic resistance | Expansion of the mandatory set of monitoring and alert systems | [4; 7] |

Source: compiled by the author from materials [4; 7; 8; 10-12].

The fourth group of findings pertains to specialized lodging for distant manufacturing locations. New settlements in arid and barren zones ought to be conceived not as fleeting quarters, but as highly operational units that guarantee hygienic security, mental ease, and digital access for laborers. For these encampments, the sealing of the building shell, air purification, scalable construction, independent utility networks, and integrated tools for observing dangerous fumes and incidents are of chief significance [5].

The fifth set of results addresses essential groundwork. For regions generating natural gas, the vital elements include: (a) dependable vehicle routes and maintenance pathways; (b) potable water and sewage arrangements with an emphasis on water economy; (c) consistent power supply; and (d) electronic linkage. Transportation linkage with main corridors is particularly crucial because

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amidst considerable geographic isolation, roadways and supply hubs dictate entry to healthcare, building materials, upkeep support, and staff. [1].

The analysis shows that engineering infrastructure should be designed as an interdependent system. For example, transport isolation increases the requirements for local reserves of water and materials; water scarcity intensifies the need for closed-loop heat-supply systems and local treatment facilities; and unstable power supply makes redundancy of critical social facilities and digital networks mandatory.

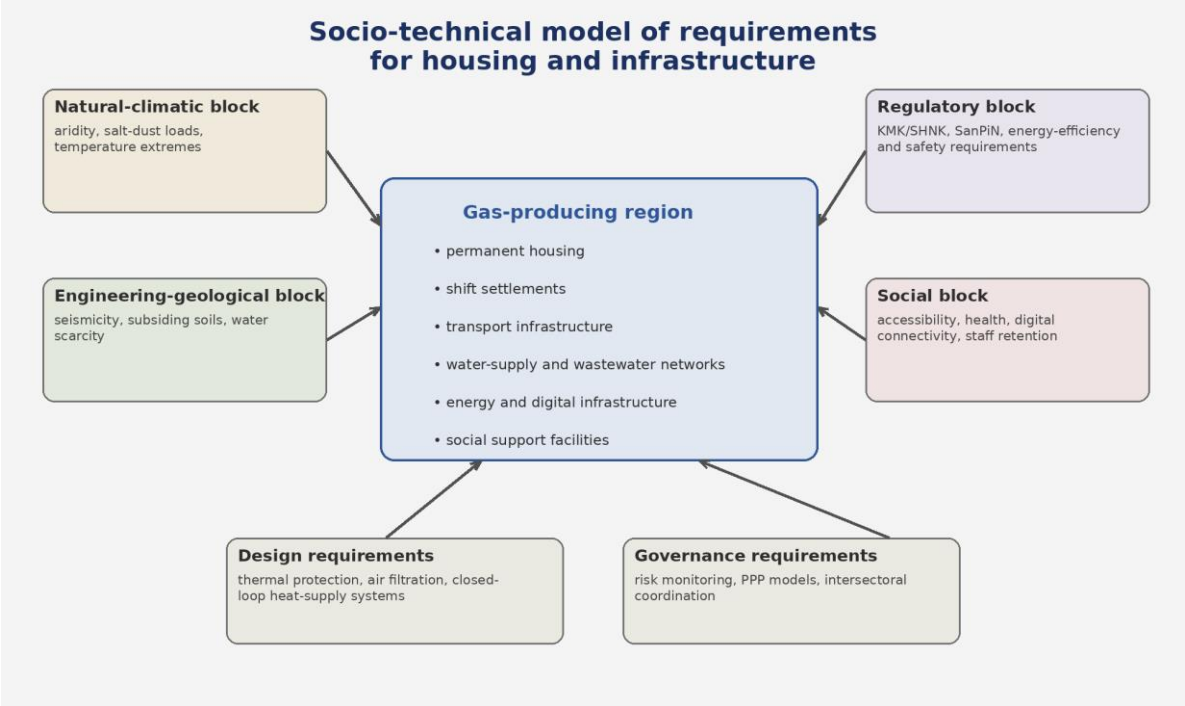


*Figure 3. Socio-technical model of housing and infrastructure requirements in a gas-producing region*

Source: compiled by the author based on the synthesis of materials [1-12].

**Discussion**

The findings achieved suggest that in gas-producing localities, accommodation and amenities should not be viewed as a mere background to industrial growth. Instead, they constitute a component of the output structure since they influence personnel retention, laborers' wellness, functional dependability, and facilities' life-cycle expenditures. This is especially clear in Karakalpakstan, where ecological strain raises the expense of any planning mistake.

Examining global practice reveals that a minimum of two growth rationales apply to Uzbekistan. The initial is the pattern of responsive architecture for dry resource-generating zones, demonstrated, for instance, in Australia's Pilbara, where significant emphasis is placed on climate-suited design, light building forms, solar shielding, and regional character [3]. The subsequent is the high-caliber standard of

rotational lodging typical of the Gulf nations, where residential caliber is considered a variable for keeping skilled staff [5].

However, a straightforward adoption of these templates to Uzbekistan is not feasible. For the circumstances of Karakalpakstan and the Bukhara Region, a mixed method is more practical: merging modularity, efficient resource utilization, robust building exteriors, and the required incorporation of communal facilities within housing schemes.

The governance dimension also deserves particular attention. International reports on Uzbekistan point to the need for intersectoral coordination among energy, construction, water management, transport, and social policy [2; 10-12]. This means that housing and infrastructure requirements should be formulated not as fragmented departmental norms, but as a unified package of design parameters for regional development programmes.

The study confirmed the significance of monitoring-based design. Under conditions of escalating climate risks in gas-producing territories, it is insufficient merely to comply with formal building regulations; projects must also incorporate design scenarios of extreme heat, dust storms, water stress, transport isolation, and failures of engineering systems.

**Conclusion**

The analysis made it possible to formulate the following conclusions.

First, Uzbekistan's gas-producing regions impose substantially more stringent requirements on housing and infrastructure than ordinary urban and rural territories. This is due to the combination of an arid climate, salt-dust exposure, water scarcity, seismicity, engineering-geological constraints, and the remoteness of production sites.

Second, permanent housing in Karakalpakstan and the Bukhara Region should be designed as an element of an integrated urbanized cluster that includes transport, utility, energy, digital, and social infrastructure.

Third, for remote sites, priority should be given to a new generation of shift settlements based on modularity, airtightness, air filtration, autonomy of engineering systems, and digital safety monitoring.

Fourth, the critical technical requirements for the study regions are enhanced thermal protection of building envelopes, overheating control, closed-loop heat-supply systems, water conservation, increased reliability of underground utilities, seismic resistance, redundancy of critical systems, and barrier-free accessibility.

Fifth, the most promising model for practice is the socio-technical one, in which the design of housing and infrastructure is linked to risk management, interagency coordination, and long-term regional development programmes.

Thus, the development of Uzbekistan's gas-producing regions should rely not on isolated industrial construction, but on the formation of a resilient living environment.

## REFERENCES:

1. Asian Development Bank. Uzbekistan: Bukhara Road Network Improvement Project (Phase 1). CAREC Program. 2020.
2. Asian Development Bank. Harnessing Uzbekistan's Potential of Urbanization: National Urban Assessment. Manila: ADB, 2021.
3. DevelopmentWA. Pilbara Vernacular Handbook: A Contemporary Design Response to the Pilbara Context. 2012.
4. Goskomarkhitektstroy. SHNK 2.07.01-03. Urban Planning. Tashkent, 2009.
5. Karmod Prefabricated Technologies. Qatar's Oil and Gas Man Camps: The Gold Standard in Housing. 2023.
6. Kuklina A., Galkina A. New Challenges for Uzbekistan's Energy Sector and the Role of the Gas Industry // E3S Web of Conferences. 2023. Vol. 470. Art. 01009.
7. Ministry of Construction and Housing and Communal Services of the Republic of Uzbekistan. ShNQ 2.04.01-22: Internal Water Supply and Sewage Disposal of Buildings. Tashkent, 2024.
8. President of the Republic of Uzbekistan. Decree on the Radical Reform of the Heat Supply Sector. 11 March 2025.
9. UNECE. Urbanization and Industrialization in Uzbekistan: Challenges, Problems and Prospects. Geneva, 2013.
10. UNICEF. A Climate Landscape Analysis for Children in Uzbekistan. New York, 2024.
11. United Nations Development Programme. Needs of Karakalpakstan's Population Based on the Consequences of Climate Change in the Aral Sea Region. 2023.
12. World Bank Group. Climate Risk Country Profile: Uzbekistan. Washington, DC, 2021.
13. UN Cartographic Section; Wikimedia Commons. File: Uzbekistan regions map.svg. 2010. URL: https://commons.wikimedia.org/wiki/File:Uzbekistan_regions_map.svg (accessed: 06.04.2026).
14. NASA; Wikimedia Commons. File: AralSea1989_2014.jpg. 2014. URL: https://commons.wikimedia.org/wiki/File:AralSea1989_2014.jpg (accessed: 06.04.2026).

15. NASA Scientific Visualization Studio. Shrinking Aral Sea. 2013. URL: https://svs.gsfc.nasa.gov/30165/ (accessed: 06.04.2026).

16. Makhamova, M. (2024). Architecture for an inclusive society: creating accessible environments for people with disabilities, designing inclusive spaces and buildings. Science and innovation, 3(C3), 120-149.

17. Bazarovna, M. M. (2023). BUILDING MULTICULTURAL ARCHITECTURE IN THE CITY ENVIRONMENT FOR THE DEVELOPMENT OF SPIRITUALITY: sacred, multiculturalism, multicultural space, model. JOURNAL OF ENGINEERING, MECHANICS AND MODERN ARCHITECTURE, 483-490.

18. Makhamova, M., & Azimova, D. (2025). Forerunners of the Study and Analysis of the Basics of the Typology of Buildings and Elements of Landscape Architecture of Modern Wellness Centers. TATALOKA Учредители: Institute of Research and Community Services Diponegoro University (LPPM UNDIP), 27(1), 95-115.

19. Rajapovna, R. G. (2025). IMPROVEMENT OF THE STAFF TRAINING SYSTEM AND REFLECTIONS ON NEW PEDAGOGY OF ARCHITECTURAL AND CONSTRUCTION EDUCATION. SHOKH LIBRARY, 1(12).

20. Smolyak, S. A., Samatov, A. S., Rakhimova, G. R., & Odilova, G. S. (2022). Joint Application Of Market And Income Approaches To New Machines And Equipment Valuation Under Uncertainty.

21. Rajapovna, R. G. (2025). IMPROVEMENT OF THE STAFF TRAINING SYSTEM AND REFLECTIONS ON NEW PEDAGOGY OF ARCHITECTURAL AND CONSTRUCTION EDUCATION. SHOKH LIBRARY, 1(12).