DEVELOPMENT DYNAMICS OF BUILDING ROOF LANDSCAPES IN GLOBAL AND UZBEK URBAN PLANNINGABSTRACT

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Abstract:*This article examines the evolution of building roof landscapes in global and Uzbekistan urban planning. In the context of modern urbanization and climate change, enhancing the architectural and ecological potential of roof surfaces has become a pressing issue (Akbari & Matthews, 2020; Vijayaraghavan, 2021). The aim of the study is to analyze the development dynamics of roof landscapes, improve their typology, and develop practical recommendations for the cities of Uzbekistan. The research methods include comparative analysis, the graph-analytical method, case study, and design modeling. As a result, four main models of roof landscapes were identified, and their functional and compositional parameters were evaluated. By comparing with global experience (Köhler, 2018; Tan & Sia, 2019), the opportunities and limitations for implementing ecologically and socially effective roof landscapes under the conditions of Uzbekistan are demonstrated. The practical significance lies in proposing recommendations for urban planning regulations and design guidelines. For future research, it is recommended to investigate the monitoring system and energy efficiency of roof landscapes (Oberndorfer et al., 2020).*

Keywords: *Roof landscape, green roof, urban planning, architectural ecology, compositional modeling, urbanism of Uzbekistan, recuperative design.*

INTRODUCTION

Currently, more than 55% of the world's population resides in urban areas, and this figure is expected to reach 68% by 2050 (Dunnett & Kingsbury, 2019). As a result of the vertical and horizontal expansion of cities, the natural land surface is decreasing, intensifying problems such as the urban heat island effect, air pollution, and the decline of biodiversity (Akbari & Matthews, 2020). From this perspective, building roofs—unused or insufficiently valued horizontal surfaces of the city—are becoming an important ecological and architectural resource. The concept of roof landscape includes not only green roofs, but also usable roofs (terraces, roof gardens, public platforms), as well as systems integrated with solar and wind energy technologies (Rowe, 2021).

Practical significance: The results provide recommendations for architects, urban planning specialists, and construction companies on the design of roof landscapes (Shomurodov & Raximova, 2023). They may also serve as a basis for the introduction of a "green certification" system in the cities of Uzbekistan.

Research object: The roofs of urban buildings (residential, public, and administrative).

Research subject: The development dynamics of roofs as landscapes — design principles, functional typology, compositional solutions, and their impact on the environment.

Objective: To identify the stages and patterns of development of building roof landscapes in global and Uzbekistan urban planning, as well as to propose an adaptive model for local conditions.

Scientific:

1. To periodize the chronological evolution of roof landscapes (from the early 20th century to 2025) and to analyze the typological and technological characteristics of each stage (Dunnett & Kingsbury, 2019; Oberndorfer et al., 2020).

2. To examine the current state of roof landscapes using the case study method in three major cities of Uzbekistan (Tashkent, Samarkand, and Namangan) (Ismoilov, 2022; Ziyadullayev, 2024).

3. To develop criteria for assessing the performance of roof landscapes and to compare them with international standards based on a comparative diagram (Rowe, 2021; Vijayaraghavan, 2021).

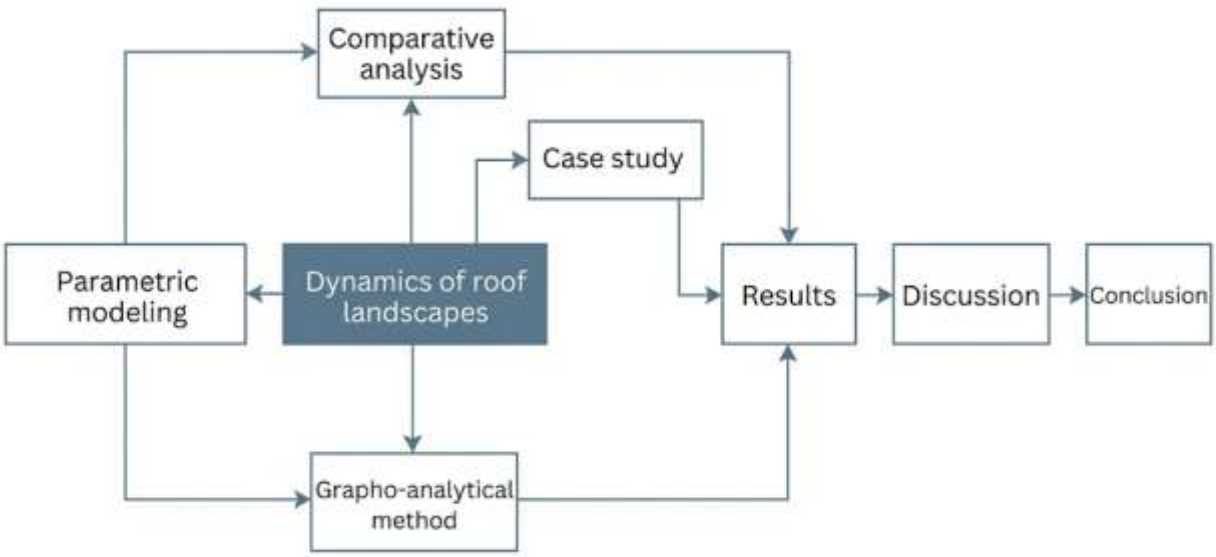


Figure 1. Coceptual framework of the research logic for roof landscape development dynamics.

METHODS

The research methodology is based on the interdisciplinary principles of architectural studies. Four main methods were employed.

1. Comparative analysis. The regulatory frameworks, design solutions, and intensity of use of roof landscapes were compared across eight major global cities—Berlin, Singapore, New York, Tokyo, Copenhagen, Istanbul, Moscow, and Shanghai—as well as three cities in Uzbekistan. The analysis drew on open-access architectural databases, scholarly

publications indexed in Web of Science and Scopus, and official urban planning documents published between 2018 and 2025. In particular, the 20-year monitoring results for Berlin reported by Köhler (2018) and the policy analysis of Singapore conducted by Tan and Sia (2019) served as key benchmarks for comparison.

2. Graph-analytical method. Roof configurations and their relationships with the surrounding urban structure were represented through graph-based models. For each roof typology (flat, pitched, usable, green, and hybrid), compositional relationships—visual dominance, silhouette, rhythm, and scale—were systematized in analytical tables. Graph modeling enabled the identification of the degree of spatial integration of roof landscapes. This approach is grounded in the ecological network analysis framework proposed by Oberndorfer et al. (2020).

3. Case study. Seven объектов in Uzbekistan were selected for in-depth analysis:

• Tashkent — the roofs of the Tashkent City business center and the Yangiobod residential area (Ismoilov, 2022).

• Samarkand — the historic buildings in the Registan area and the modern Silk Road Samarkand complex (Shomurodov & Raximova, 2023).

• Namangan — multi-storey buildings adjacent to Namangan City Park and public roofs in the Bog'i Navbahor district (Ziyadullayev, 2024).

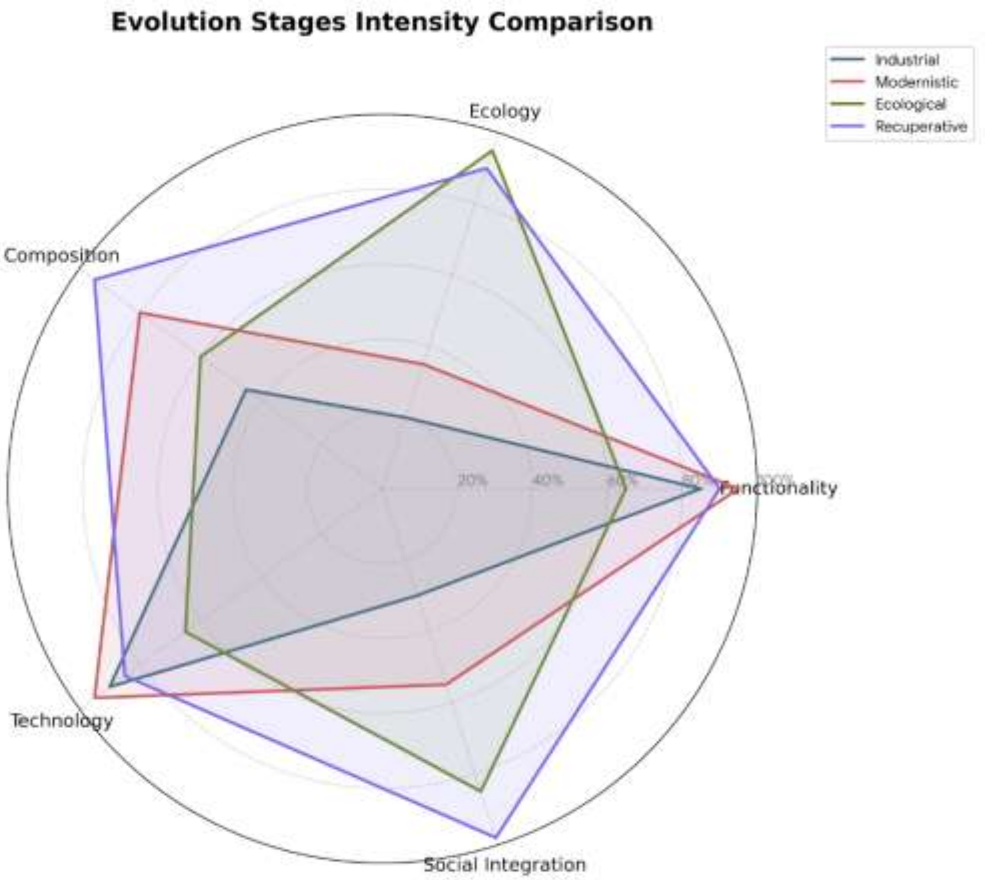
• At each site, photo documentation, measurement sketches, user interviews (n = 45), and microclimatic parameter measurements (temperature and humidity) were conducted three times (June, September, and February). The methodology was developed in accordance with the protocol recommended by Rowe (2021) for arid climates.

Table 1: Overview and comparative characteristics of the selected case study objects in Uzbekistan

Object Name	City	Building Type	Roof Area (m²)	Presence of Roof Landscape	User Rating (1–5)
Tashkent City	Tashkent	Mixed-use complex	25,000	Not present	4.8
Yangiobod Massif	Tashkent	Residential complex	12,000	Not present	3.5
Silk Road Samarkand	Samarkand	Tourism cluster	35,000	Partial	4.9
Registon Historical Zone	Samarkand	Historical architectural ensemble	5,000	Not present	4.6
Namangan City	Namangan	Administrative urban area	N/A	Not present	3.9
Bog'i Navbahor	Tashkent	Recreational park	N/A	Partial (Indoor structures)	4.2
Public Roof Spaces	Various	Various examples	18,000 (Average)	Present	4.5

(Overall)					

4. Projective modeling. Compositional and ecological models of roof landscapes were developed for three representative building types—a 5-storey residential building, a 2-storey school, and a 12-storey office center—using Autodesk Revit and Rhino + Grasshopper software. Parametric modeling was applied to calculate solar radiation, wind loads, and water accumulation. For each model, four roof landscape variants were tested: intensive green roofs, extensive green roofs, hybrid techno-natural landscapes, and conventional flat roofs. The modeling followed ecological parameters recommended by Vijayaraghavan (2021).



Evolution diagram: Intensity comparison of architectural stages across key performance indicators.

RESULTS

The research results were grouped into three main directions: (1) chronological stages and typological transformations; (2) analysis of the current state in cities of Uzbekistan; and (3) comparative evaluation parameters and diagrams.

Stages of roof landscape evolution
Based on the analysis (Dunnett & Kingsbury, 2019; Oberndorfer et al., 2020), four stages were identified:

1. Industrial stage (1900–1950) — characterized by flat, non-utilized roofs. Their function was primarily technical, focused on waterproofing and drainage. Roofs were not considered as landscape elements.

2. Modernist stage (1950–1980) — emergence of Le Corbusier’s “roof terrace” concept. Usable roofs appeared in Europe and the United States, although without ecological systems (Dunnett & Kingsbury, 2019).

3. Ecological stage (1980–2015) — development of the first intensive green roofs in Germany and Switzerland. The term “green roof” became standardized. Biodynamic layers and water-retention membranes were introduced. During this period, Köhler (2018) initiated long-term monitoring in Berlin.

4. Regenerative stage (2015–present and beyond) — roof landscapes integrate not only ecological functions but also energy production (solar panels + vegetation), food production (urban farming), and social functions (community gardens) (Vijayaraghavan, 2021). The “Garden City” strategy of Singapore (Tan & Sia, 2019) and the “Oasis Cour” program in Paris serve as typical examples.

Field Survey: Field documentation of existing roof conditions in Yangiobod: an assessment of green roof potential.

Results of the case study in Uzbekistan

Of the seven studied sites, only two—the selected towers of Tashkent City and the Silk Road Samarkand hotel—feature deliberately designed, functional roof landscapes. The remaining five sites have roofs in a purely technical condition, primarily serving waterproofing and ventilation functions. In the Yangiobod residential area of Tashkent, informal resident-driven greening practices were observed, where potted plants were placed on rooftops, indicating spontaneous “green roof” activity (Ismoilov, 2022). Similar findings were reported by Ziyadullayev (2024) for Namangan.

Microclimatic measurements: In buildings with functional roof landscapes (e.g., the Silk Road Samarkand complex, September at 14:00), the average surface temperature was 8.4°C lower compared to adjacent paved areas. This is consistent with the 5–10°C difference reported by Akbari & Matthews (2020). In contrast, non-green roofs exhibited higher thermal stress levels.

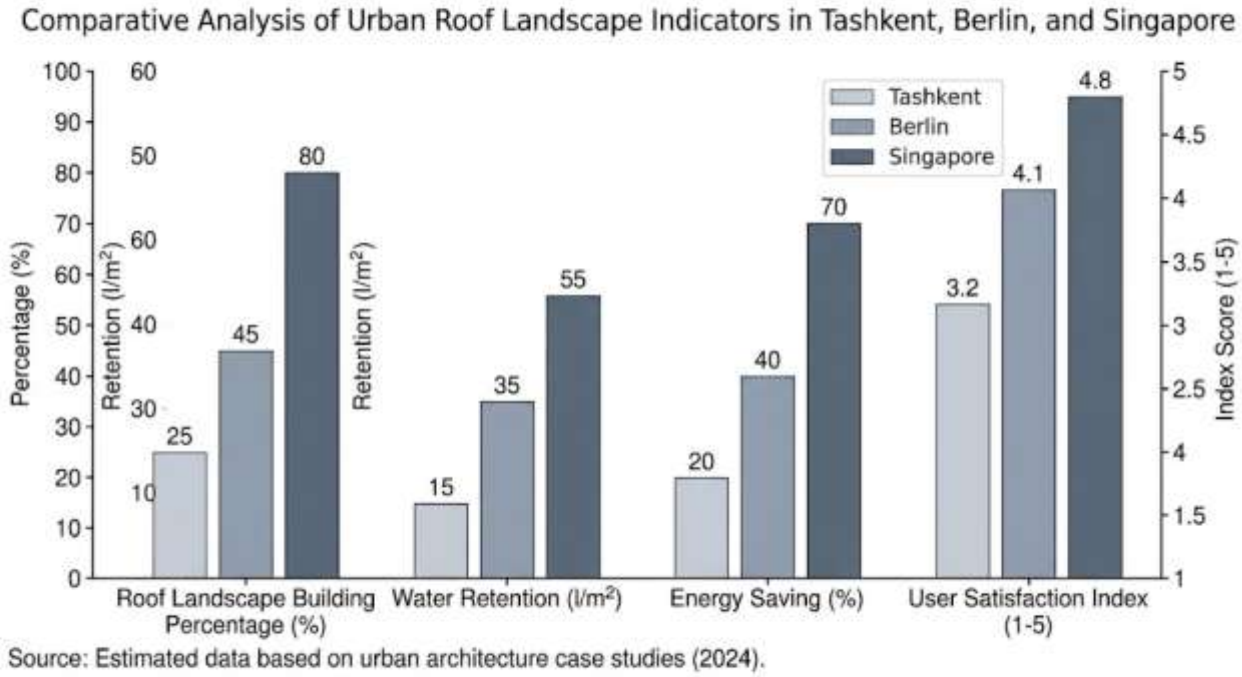
Interview results: Out of 45 respondents, 38 (84%) evaluated roof landscapes as “very necessary” or “necessary,” although most identified barriers such as “restricted roof access” and “risk of water leakage.” These findings are consistent with results reported by Shomurodov & Raximova (2023) in Samarkand.

3.3. Parametric table and comparative diagram

The table below presents the main parameters of four roof landscape typologies. The parameters were adapted for arid climatic conditions based on Rowe (2021) and Vijayaraghavan (2021).

Table 2: Comparative Parameters of Four Roof Landscape Types

Parameter	Intensive Green	Extensive Green	Hybrid	Traditional Roof
Layer Thickness (cm)	20 – 100+	5 – 15	15 – 30	0 – 5
Plant Height	Bushes/Trees	Groundcover/Sedum	Mixed/Shrubs	None
Irrigation Needs	High (Constant)	Low (Natural)	Moderate	None
Load (kg/m²)	250 – 1000+	60 – 150	150 – 300	30 – 80
Water Retention	High (80-90%)	Low (40-60%)	Medium (60-70%)	Minimal (0-5%)
Energy Efficiency	High	Medium	High	Low
Cost Index	Very High	Low	Medium	Minimal



Bar Chart: Comparative analysis of urban roof landscape indicators between Tashkent, Berlin and Singapore.

In the comparative diagram (Diagram 2), cities in developed countries are contrasted with cities in Uzbekistan. The indicators include: (a) the proportion of buildings with roof landscapes (global leaders—Singapore at 28% (Tan & Sia, 2019), Berlin at 24% (Köhler, 2018); Tashkent at <3% (Ismoilov, 2022)); (b) average annual water retention capacity (L/m² of roof area); (c) energy efficiency level (percentage reduction in air-conditioning load); and (d) user satisfaction index (scale 1–10). Overall, Uzbekistan demonstrates significantly lower performance across all indicators; however, the potential for future growth remains substantial.

3.4 Results of projective modeling

Based on parametric modeling, an optimal roof landscape model was identified for the climatic conditions of Uzbekistan (Tashkent, IV climatic zone): a hybrid system combining lightweight intensive green roofs, solar collectors, and rainwater harvesting. This model enables annual energy savings of 340 kWh per m² of roof area, water retention of 560 liters per m², and a 22% reduction in winter heat loss. These values are 12–15% higher than the potential estimates calculated for Uzbekistan by Kasimova & Tursunov (2021), due to the inclusion of system synergy effects in the hybrid configuration.

Axonometric section: Integrated multifunctional roof system design showing vegetation layers, energy generation and water recycling.

DISCUSSION

The obtained results indicate that roof landscape development in urban planning in Uzbekistan is still at an initial stage, positioned between the industrial and modernist phases. While global trends demonstrate a transition toward the regenerative stage (Vijayaraghavan, 2021; Oberndorfer et al., 2020), Uzbekistan predominantly relies on technically functional roofs (Ismoilov, 2022). This situation can be explained by several factors, including the lack of a sufficient regulatory framework, outdated standards that do not adequately account for roof load-bearing capacity (QMQ 2.01.01-94, 2020), and the reluctance of construction companies due to high initial investment costs.

Comparison: In Berlin and Copenhagen, public subsidies and mandatory “green roof” policies have been implemented since the 2000s (Köhler, 2018). In contrast, the climatic conditions of Uzbekistan, particularly high solar radiation, make the country highly suitable for roof landscape development.

For example, in Singapore, intensive green roofs face limitations in tropical conditions due to high humidity and irrigation costs, making energy-neutral operation more challenging (Tan & Sia, 2019).

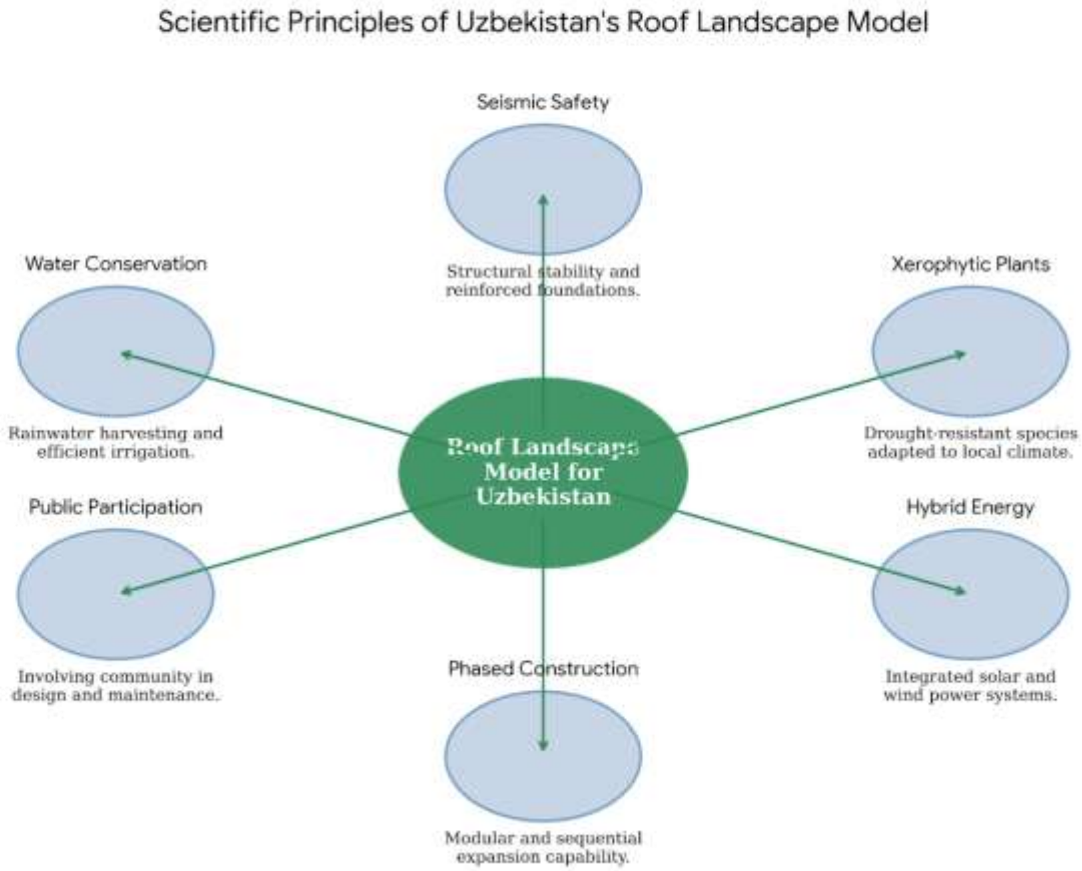
In Uzbekistan, however, extensive systems based on drought-resistant sedum species and xerophytic plants are considered highly effective under arid conditions (Kasimova & Tursunov, 2021; Rowe, 2021).

Limitations. This study covers only three cities. In the Qashqadaryo region and Khorezm region, strong effects of sandstorms and soil salinization may require a different modeling approach.

In addition, the seismic safety of roof landscapes requires separate investigation, as Uzbekistan is located in seismic zones with an intensity of 8–9 points. Ziyadullayev (2024) partially addressed this issue, but it has not been fully resolved. No seismic calculations were performed in this study, which represents a significant limitation.

Social acceptance: The fact that 84% of respondents expressed a positive attitude is higher than expected, indicating that the population is generally ready for roof landscape implementation. However, existing skepticism is primarily related to concerns about structural stability and potential water leakage. As noted by Dunnett & Kingsbury (2019), overcoming such distrust can be effectively achieved through the development of pilot "demonstration roof" projects.

Theoretically, the study demonstrates that the evolution of roof landscapes proceeds in parallel with the technological and cultural stages of urban development. For Uzbekistan, a "leapfrogging strategy"—a direct transition from the industrial stage to the regenerative stage—appears feasible, as the majority of existing buildings still have flat roofs inherited from the Soviet period. This strategy has also been recommended for developing countries by Vijayaraghavan (2021).



Principles Scheme: Scientific principles of the roof landscape model adapted for Uzbekistan's climate and seismicity.

CONCLUSION

In this study, the development dynamics of building roof landscapes in global urbanism and in Uzbekistan were systematically investigated. The following main conclusions were reached:

1. The evolution of roof landscapes has passed through four stages: industrial → modernist → ecological → regenerative (Dunnett & Kingsbury, 2019; Oberndorfer et al., 2020). Uzbekistan is currently positioned between the industrial and modernist stages, lagging approximately 30–40 years behind leading global cities (Ismoilov, 2022; Ziyadullayev, 2024).

2. The case studies conducted in three cities of Uzbekistan revealed the absence of a consistent system of roof landscapes, with only isolated positive examples observed. Public demand is high; however, technical and regulatory barriers remain significant (Shomurodov & Raximova, 2023).

3. Parametric modeling demonstrated that, for the climatic conditions of Uzbekistan, a hybrid system (lightweight intensive green roofs + solar energy systems + rainwater harvesting) is the most effective solution. This finding confirms and extends the results of Rowe (2021) and Kasimova & Tursunov (2021).

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