LANDSCAPE DESIGN SOLUTIONS FOR GREEN ROOFS IN RESIDENTIAL COMPLEXES

Muhammadsolih Komiljonov
PhD, Associate Professor
Muslima Sobitova
Master’s Student
Tashkent University of Architecture and Civil Engineering

Abstract: *This scientific article examines landscape design solutions for green roofs in residential complexes, which represent one of the pressing issues in modern urban planning. The relevance of the study is associated with the need to develop vertical components of urban landscapes in response to increasing urbanization, the “urban heat island” effect, and environmental degradation.*

The aim of the study is to develop a scientifically grounded methodology for utilizing residential building roofs for recreational and ecological purposes. During the research, methods such as system analysis, comparative case studies, and design modeling were applied.

As a result, the structural and technological parameters of green roofs were identified, and their functional-spatial models were proposed. The scientific novelty of the research lies in the systematization of principles for forming plant associations based on climatic factors and the ergonomic placement of landscape elements.

The practical significance of the study is determined by the applicability of the developed recommendations in improving energy efficiency and creating a comfortable microclimate in modern residential architecture. The obtained results can serve as a methodological basis for specialists in landscape design and urban ecology.

Keywords*: Green roof, landscape architecture, residential complex, ecological design, vertical greening, urban microclimate, sustainable architecture.*

1. INTRODUCTION

In modern urban planning theory and practice, the concept of sustainable development of residential complexes is directly linked to maintaining harmony with nature. The global process of urbanization has led to limited land resources and increased building density in urban centers, resulting in a significant reduction of traditional horizontal green spaces.

In such conditions, green roof technology emerges as an innovative and effective solution in landscape design. Green roofs not only enhance the aesthetic quality of buildings but also act as an essential component of the urban ecosystem by regulating the microclimate, improving air quality, and contributing to stormwater management.

Relevance of the study: In the context of Uzbekistan, particularly in large metropolitan areas such as Tashkent, there is a growing demand for vertical greening solutions to reduce heat loads and meet the recreational needs of residents.

The object of the study is the roof spaces of multi-story residential complexes, while the subject focuses on the principles and compositional methods for shaping their landscape design solutions.

Problem statement: Uzbekistan’s sharply continental climate—characterized by hot and dry summers—requires specific engineering and design approaches for green roofs. Conventional methods may not yield the expected results under such conditions.

Research objective: To develop scientific and methodological recommendations for creating sustainable and functional landscape environments on residential building roofs. To achieve this goal, the following tasks were set:

- analyze global trends in green roof design;
- study the structural and functional capacities of residential rooftops;
- model spatial compositions of landscape elements.

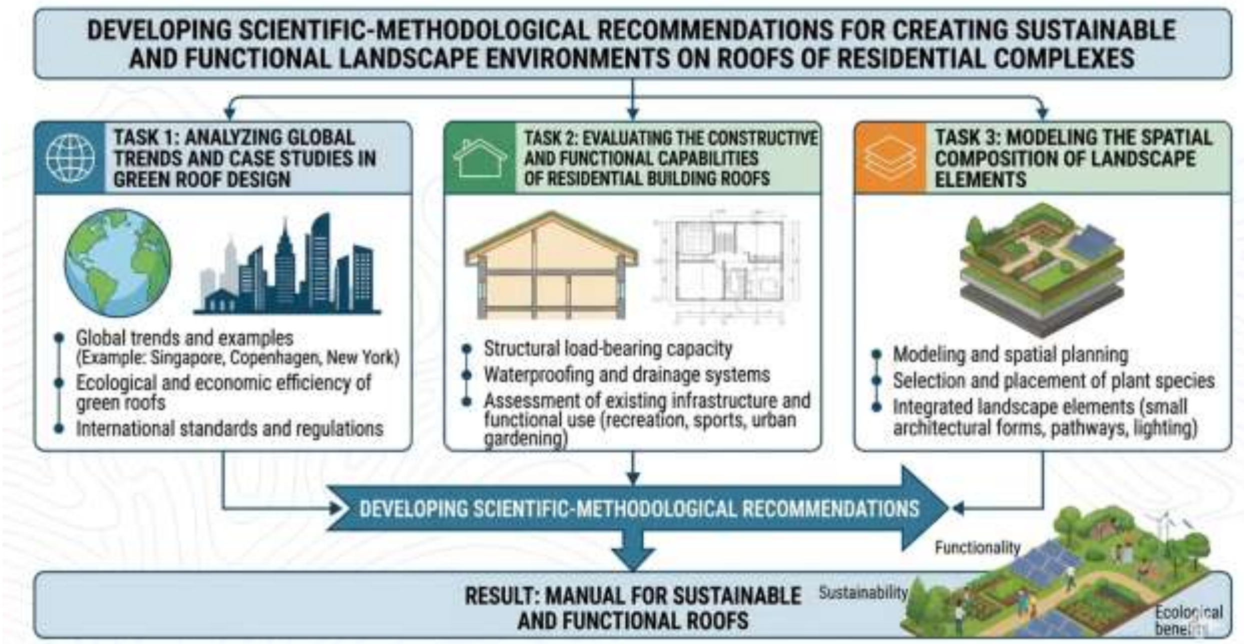

Figure-1: Structural scheme of scientific-methodological recommendations: creating sustainable landscape environments on roofs of residential complexes.

Scientific novelty of the research: The scientific novelty of the study lies in the fact that, for the first time, it proposes the concept of considering the roofs of residential complexes as “multi-functional green modules,” in which engineering-technical and aesthetic-ecological parameters are integrated into a unified system.

2. Methods:

In this study, a comprehensive approach in the fields of architecture and landscape design was applied, and the methodology encompasses several stages of scientific research.

First, through the method of comparative analysis, the regulatory requirements and design trends of green roof architecture in developed countries (Germany, Canada, and

Singapore) were examined. This analysis enabled a comparison of the efficiency indicators of extensive and intensive greening types within the residential sector.

In the second stage, a graph-analytical method was employed to analyze spatial dimensions, solar exposure (insolation), and wind patterns of residential building rooftops in a graphical format. This method made it possible to determine ergonomic layout schemes for functional zones on rooftops, including recreation, play, and technical areas. Additionally, the case-study method was used to examine existing modern residential complexes in Tashkent and Baku as real examples, evaluating their climatic adaptability as well as the strengths and weaknesses of their landscape design solutions.

In the third and final stage, theoretical conclusions were translated into visual form through design modeling. In this process, modular schemes were developed by taking into account the load exerted by landscape components (plants, small architectural forms, and water features) on the building’s structural framework. The interconnection between engineering-technical layers (waterproofing, drainage, and substrate) and the methodology for selecting plant associations constitute the core of this methodology.

Stages	Applied methods	Analyzed Indicators	Expected Results
Stage 1: Theoretical and Comparative Analysis	Comparative analysis, analysis of regulatory documents	Experience of Germany, Canada, and Singapore; types of extensive and intensive greening.	Identification of regulatory requirements and design trends based on international experience.
Stage 2: Graph-Analytical Method and Case Study	Graph-analytical method, Case study (Tashkent, Baku)	Insolation, wind patterns, ergonomics; climatic adaptability of existing complexes.	Optimal layout schemes of functional zones (recreation, play areas) and analysis of shortcomings.
Stage 3: Design Modeling	Visual modeling, engineering calculations	Structural load, waterproofing, drainage, and substrate layers; plant associations.	Development of modular schemes, integration of technical layers, and creation of a sustainable landscape model.

Table 1: Stages of the methodology for creating a landscape environment on the roofs of residential complexes.

3. Results:

The results of the conducted research indicate that the success of landscape design in organizing green roofs within residential complexes depends on the harmonious interaction of three key factors: structural stability, functional diversity, and ecological sustainability. During the study, the main principles for shaping landscape design solutions on residential rooftops were identified.

First, a differentiated parameter framework was developed for the layered structure of green roofs and their thickness. It was found that in extensive greening systems, the substrate thickness ranges from 8 to 15 cm and is primarily intended for low-maintenance plants (such as sedum species). In contrast, in intensive systems, this parameter can reach from 30 cm up to 1 meter, allowing for the planting of larger shrubs and even trees.

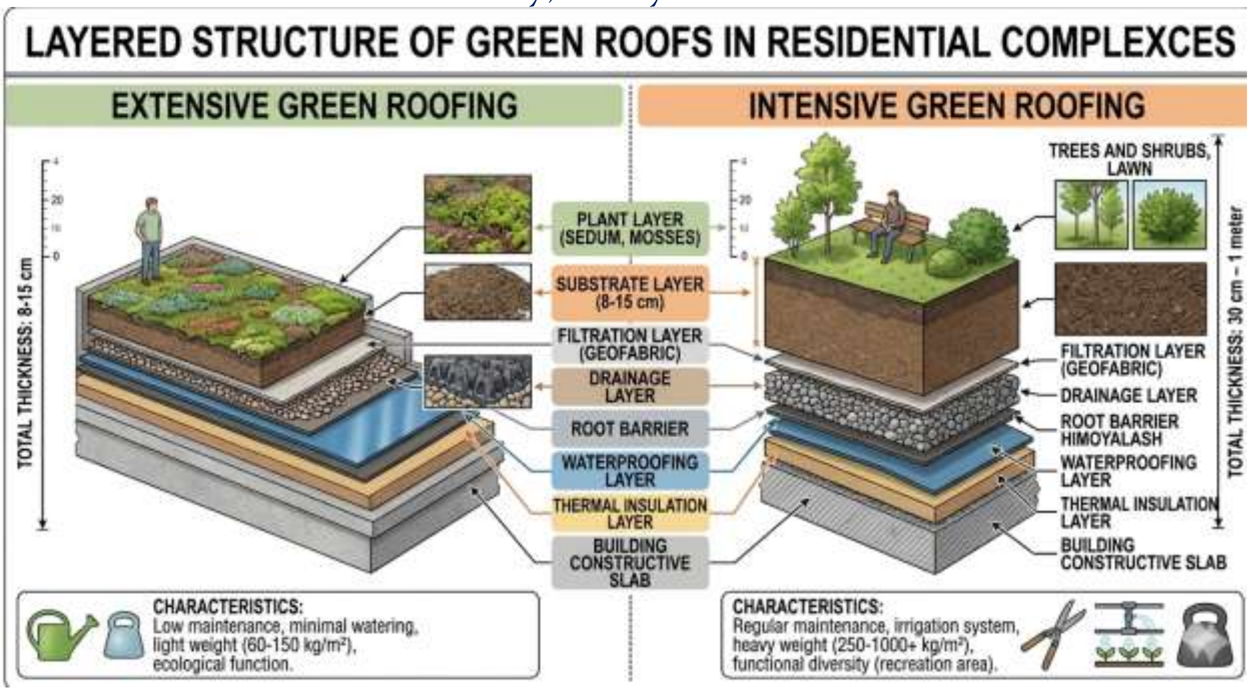

Diagram-1: Differentiated structural parameters of green roof systems in residential complexes (extensive vs intensive).

As a second result, the distribution of recommended functional zones and their area proportions for residential building rooftops were determined. The study showed that, for an optimal landscape design solution, 40–50% of the roof area should be allocated to landscaped “green modules,” 20–30% to pedestrian pathways and hard surfaces, and the remaining portion to small architectural forms (such as pergolas and seating) as well as engineering and technical zones.

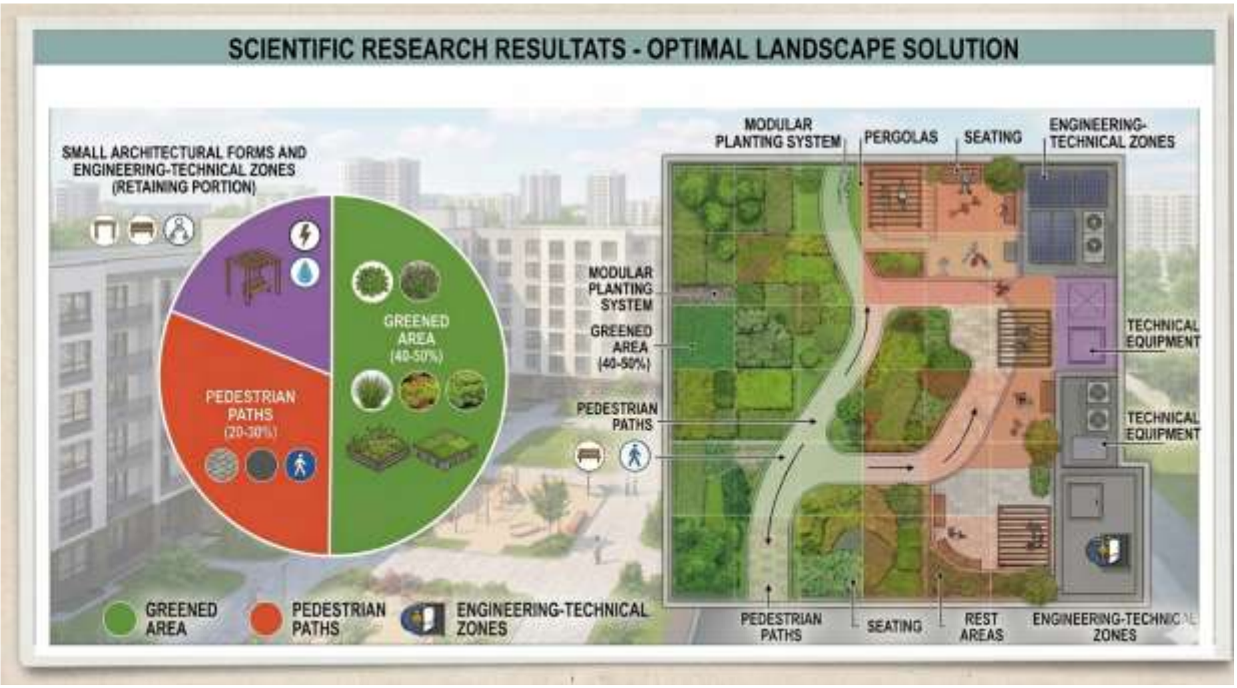

Figure-2: Rekommieded functional zones dispredition for roofs of residential buildings.

The project models demonstrated that the implementation of vertical greening systems can reduce temperatures on the upper floors of buildings by up to 4–6°C during the summer season. This not only contributes to energy savings but also significantly increases the market value of residential properties and enhances the psychophysiological comfort of residents.

From a design perspective, the creation of plant groupings at varying heights (a multi-layered landscape) ensures visual depth and enhances the compositional attractiveness of the rooftop.

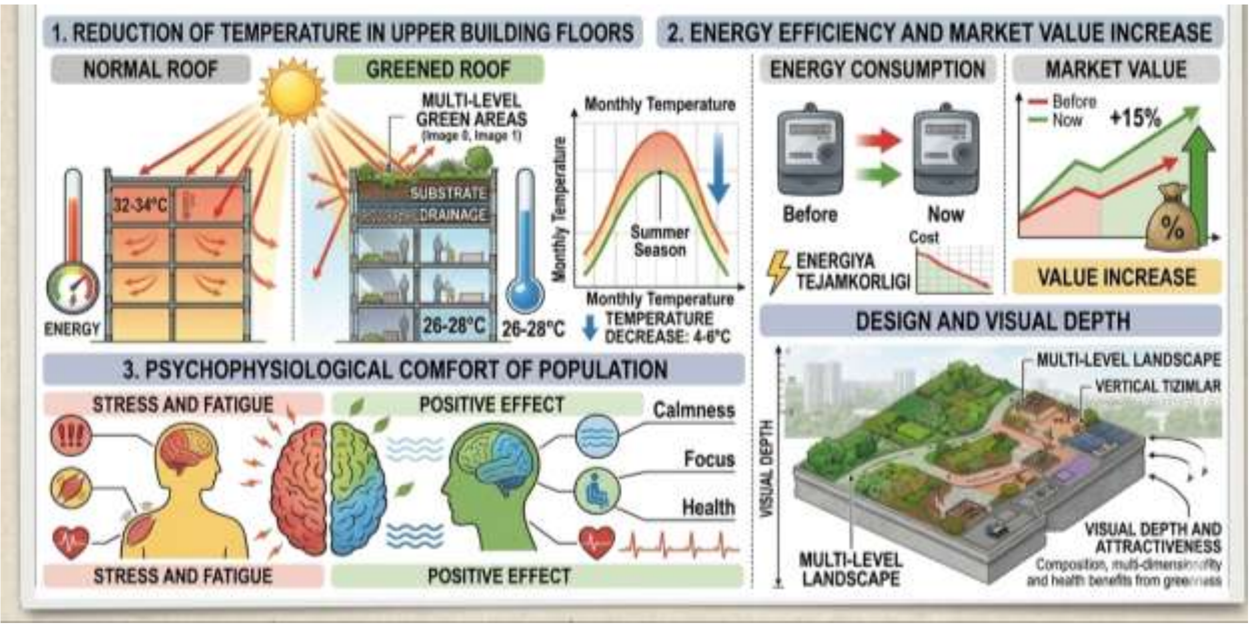

Figure-3: Complex effect of vertical greening and multi-level landscaping.

4. Discussion:

The interpretation of the research results indicates that green roofs in residential complexes are not merely “gardens,” but rather complex bio-engineering systems. When comparing the obtained findings with international studies, particularly Singapore’s “Landscaping for Urban Spaces and High-Rises” (LUSH) program, it becomes evident that our proposals place greater emphasis on adaptation to arid climates (xerolandscape principles). While water conservation is important in global practice, in tropical regions excessive humidity can be an issue; in our conditions, however, the design of green roofs in combination with automated drip irrigation systems and sun-shading structures is of decisive importance.

As for the limitations of the study, it should be noted that the structural framework of buildings—especially older residential structures—has limited capacity to withstand additional roof loads. In such cases, the use of lightweight extensive green roof modules is recommended. Additionally, the lack of specialized коммунal (municipal) service infrastructure for the maintenance and upkeep of green roofs may create practical challenges.

Nevertheless, the aesthetic and ecological integration of green roofs remains a fundamental component of the “Green City” concept. In the future, research in this field can be further developed by exploring the efficiency of integrating green roofs with solar panels (biosolar roofs), which could represent a new stage in achieving energy independence.

CONCLUSION

The conducted scientific research made it possible to establish the theoretical and practical foundations for designing green roofs in residential complexes. The following key conclusions were formulated:

1. Green roofs serve as a tool of “ecological regeneration” in residential architecture, enhancing both the aesthetic value and functionality of buildings.

2. For a successful landscape design solution, it is necessary to ensure the integration of multi-layered structural systems (hydro- and vapor insulation, drainage, substrate) with climate-adapted xerophytic plants.

3. Functional zoning must provide a comfortable (inclusive) ergonomic environment for all population groups, including people with disabilities.

As a practical recommendation, designers are advised to consider rooftops as recreational spaces from the earliest stages of residential building design and to plan the integration of engineering networks (water and electricity) onto the roof.

Future research should focus on the mathematical modeling of the economic efficiency of green roofs and the integration of vertical farming elements into the urban landscape.

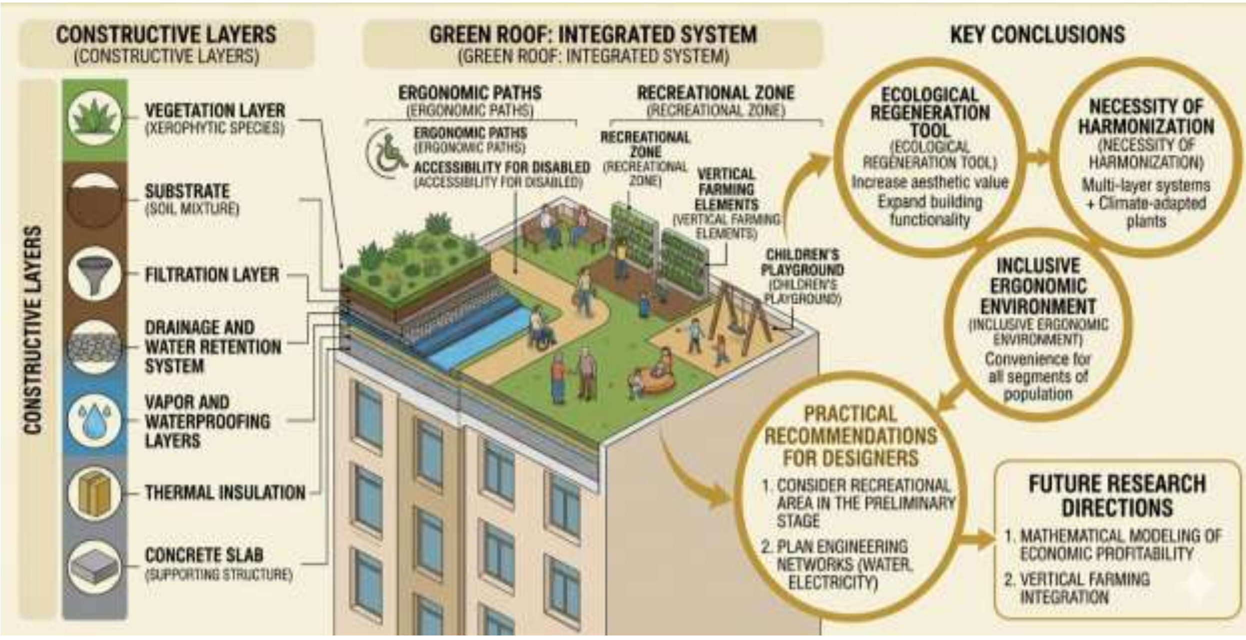

Figure-4: Theoretical and practical bases model for designing green roofs in residential complexes.

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