EVALUATING THE ECOLOGICAL, ECONOMIC, AESTHETIC, AND MICROCLIMATIC PERFORMANCE OF ECO-ART CONTAINER SYSTEMS IN URBAN ENVIRONMENTS, ROOFTOP GARDENS, AND INTERIOR SPACES

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Abstract. The rapid pace of urbanization has led to the reduction of green spaces, the intensification of the urban heat island effect, and an increase in the amount of underutilized rooftops and open spaces, necessitating the development of next-generation green infrastructure solutions. The aim of this study is to evaluate the ecological, economic, aesthetic, and microclimatic efficiency of a combinatorial modular mobile eco-art container system and xerophytic landscape elements designed for urban environments, rooftop gardens, and interior spaces. As a result of the research, an innovative smart green infrastructure technology for landscape design was developed, consisting of an internal functional structure (vegetation layer, substrate, geotextile filter, and expanded clay drainage layers) and an external decorative component (a polymer art object featuring imitations of traditional ceramic tilework and wood carving ornaments). The system is integrated with LED lighting, solar energy modules, a metal-framed glass bench, and 360° swivel lockable casters.

The use of *Sempervivum tectorum*, *Sedum acre*, *Sedum spurium*, and *Portulaca grandiflora* as the primary vegetation layer is recommended. According to the calculations, the weight of a single module ranges from 26 to 34 kg, while the installation of four modules per square meter produces a load of 103–136 kg/m². The system is capable of reducing surface temperatures by 8–12°C and ambient air temperatures by 2–4°C, capturing up to 10–15% of airborne particulate matter, decreasing irrigation water consumption by 60–80%, and reducing energy consumption by 15–25%. The scientific novelty of the study lies in the integration of smart green infrastructure technologies, mobile greening systems, traditional national decorative arts, and xerophytic landscape elements into a unified combinatorial system.

Keywords: combinatorial modular mobile eco-art container system; smart green infrastructure; xerophytic landscape elements; succulent plants; rooftop gardens; urban heat island effect; urban microclimate; mobile landscape design; ecological sustainability; energy efficiency; *girih* and *islimi* patterns; landscape design with national identity.

I. INTRODUCTION

The rapid pace of urbanization in the twenty-first century has led to the reduction of natural landscapes, the decline of green infrastructure elements, and the intensification of the urban heat island effect in urban areas, making it one of the major global environmental challenges [1]. According to the United Nations, nearly 68% of the world's population is expected to reside in cities by 2050 [2]. As a result, natural green spaces are shrinking, while the proportion of buildings and impervious surfaces continues to increase. Recent studies indicate that, due to the urban heat island effect, temperatures in central urban areas can be on average 1–7°C higher than in surrounding suburban areas, and in some cases may exceed them by up to 10°C [3].

Extensive scientific research has been conducted in Europe, North America, and Asia to mitigate these challenges through the development of green infrastructure. Oberndorfer et al. emphasize that green roofs serve as a vital component of urban ecosystems by reducing ambient temperatures, retaining stormwater, and enhancing biodiversity. A meta-analysis conducted by Berardi et al. demonstrated that green roofs can reduce building energy consumption by 15–25%. Furthermore, studies by Getter and Rowe revealed that extensive green roof systems can lower roof surface temperatures by 10–30°C [4].

In the Republic of Uzbekistan, the development of green infrastructure has also been identified as a priority area of state policy. In particular, Presidential Decree No. PF–81 of May 31, 2023, outlined measures for further expanding the nationwide "Yashil Makon" ("Green Space") initiative. Within the framework of this program, billions of trees and shrubs are to be planted throughout the country, increasing the proportion of green areas and fostering an environmentally sustainable urban environment. At the same time, the need for innovative greening systems that use water resources efficiently is becoming increasingly important in cities with arid continental climates, such as Samarkand, Bukhara, and Karshi [19].

Most existing studies focus on stationary green roofs, vertical gardens, or conventional container-based greening systems. However, adaptive, mobile, combinatorial modular, and culturally integrated smart green infrastructure systems designed for underutilized rooftops, public recreational spaces, and interior environments in arid climatic conditions remain insufficiently explored. In particular, research integrating xerophytic plants (succulents-plants adapted to water-scarce environments that store moisture in their leaves, stems, or roots and are characterized by high tolerance to drought, elevated temperatures, and intense solar radiation), energy-efficient technologies, solar-energy modules, and elements of traditional decorative arts into a unified system is still very limited.

From this perspective, the development of a combinatorial modular mobile Eco-Art container system and xerophytic landscape elements for urban environments, rooftop gardens, and interior spaces, as well as the assessment of their ecological, economic, aesthetic, and microclimatic performance, represents an important and highly relevant scientific and practical research task.

II. MATERIALS AND METHODS

Research Object. The research focused on the “Combinatorial Modular Mobile Eco-Art Container System” and “Xerophytic Landscape Elements”, designed to enhance the ecological, aesthetic, and functional qualities of urban environments, rooftop gardens, and interior spaces. The proposed system was developed for application in regions characterized by an arid continental climate, particularly in the case of Samarkand, with the aim of mitigating the urban heat island effect, transforming underutilized rooftops and open spaces into recreational areas, and promoting the efficient use of water and energy resources.

During the study, the constructive-parametric characteristics, ecological and economic performance, as well as the operational potential of the system were comprehensively evaluated. The proposed solution consists of a two-part modular structure, where the inner functional container accommodates the vegetation layers, while the outer decorative container forms an Eco-Art composition based on elements of national cultural identity [5].

The geometric dimensions of each container module are 500 × 500 × 250 mm. The effective vegetated area of a single module is 0.25 m², allowing four modules to be installed on one square meter of roof surface. Calculations revealed that the total structural weight of a single module ranges between 26–34 kg, while the corresponding static load imposed on a roof surface is approximately 103–136 kg/m². These values fall within the recommended range of 60–150 kg/m² for extensive green roof systems commonly applied in international practice (Table 1) [7].

Table 1.

Main Technical and Parametric Characteristics of the Combinatorial Modular Mobile Eco-Art Container System

Parameter	Value
External dimensions	500 × 500 × 250 mm
Vegetated area per module	0.25 m^2
Number of modules per 1 m^2	4 units
Substrate layer thickness	80 mm
Drainage layer (expanded clay)	40 mm
Geotextile filter layer	2–3 mm
Weight of one module	26–34 kg
Static load per 1 m^2	103–136 kg/m^2
Mobility system	4 swivel caster wheels with 360° rotation and brakes
Additional components	LED lighting, solar panel, glass tabletop with metal supports

Structural Design of the Combinatorial Modular Mobile Eco-Art Container

The proposed system consists of two main structural components:

I. Internal Functional Module: 1) Polymer vegetation container; 2) Lightweight engineered substrate layer with a thickness of 80 mm; 3) Geotextile filter layer; 4) Expanded clay (LECA) drainage layer with a thickness of 40 mm; 5) Vegetation medium designed for succulent plants.

II. External Decorative Module: 1)Polymer outer casing; 2) Four decorative panels featuring ceramic tile and wood-carving imitations based on traditional Islimi and Girih ornamental patterns; 3) Four-sided LED lighting system; 4) Solar energy module; 5) Transparent recreational tabletop supported by metal columns; 6) Four 360° rotating caster wheels with locking brakes.

This structural solution ensures rapid assembly, convenient transportation, and flexible relocation of the modules. Unlike conventional stationary green roof systems, the proposed system allows the configuration to be modified during operation and enables the creation of new landscape compositions according to the functional requirements of a particular site.

The structural load was calculated using the following equation:

$$Q = \frac{M}{A}$$

where: Q - structural load on the roof surface (kg/m²); M - total mass of the container module including substrate, drainage layer, decorative components, and vegetation (kg); A - effective occupied area of the module (m²).

For a module area of 0.25 m² and a total weight of 26–34 kg, the calculated load is:

$$Q_{min} = \frac{26}{0.25} = 104\, kg/m^2 \qquad Q_{max} = \frac{34}{0.25} = 136\, kg/m^2$$

Thus, the proposed Eco-Art container system generates a static roof load ranging from 103–136 kg/m², which complies with the recommended load range for extensive green roof systems and is suitable for application on most reinforced concrete roof structures (Figure 1)[6].

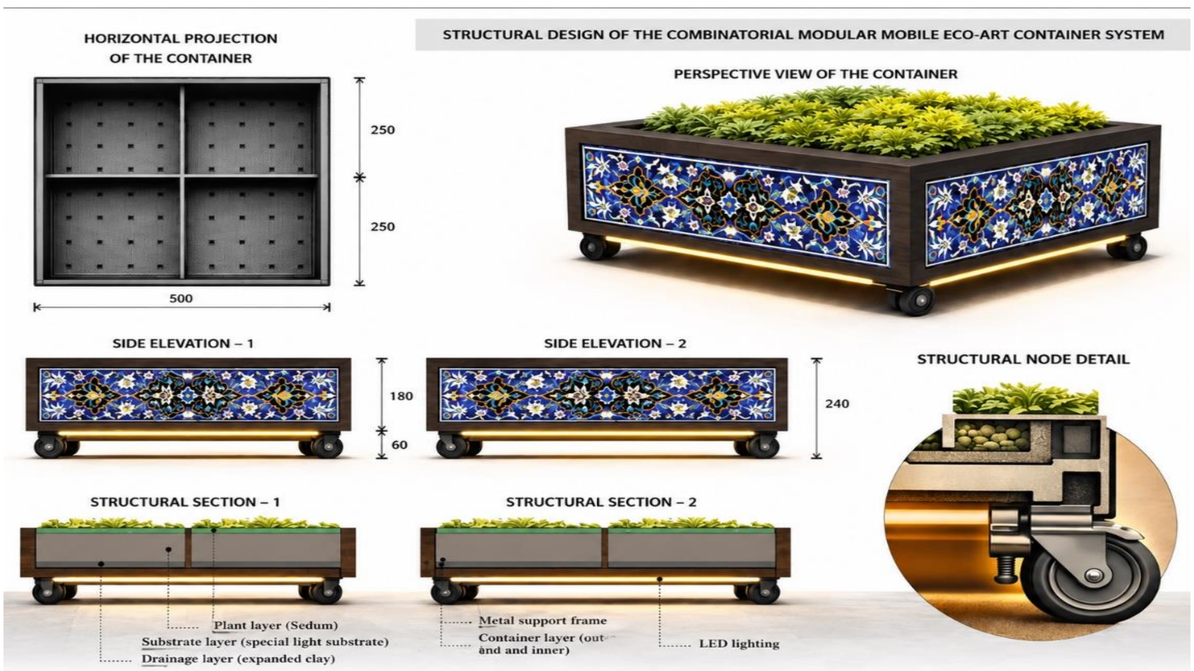

Figure 1. Structural drawing of a combinatorial modular mobile Eco-Art container made of polymer (plastic) material with decorative glazed-tile ornamentation in an imitated Islimi pattern style. Author: U.N. Karimov.

Materials and Technical Parameters

In developing the combinatorial modular mobile Eco-Art container structure, the study was based on the principles of environmental sustainability, operational convenience, structural durability, and minimizing static loads imposed on roof structures. The main structural components of the system include high-density polymer materials, lightweight vegetation substrate, geotextile filter fabric, expanded clay (LECA) drainage layer, LED lighting modules, and solar energy panels. These materials represent technological solutions widely applied in international green roof systems and modular landscape constructions.

The selection of polymer materials is justified by their corrosion resistance, non-absorbent properties, stability against ultraviolet radiation, and a specific weight that is 3–5 times lower than that of steel and concrete structures. Consequently, the application of such modules on roof structures significantly reduces additional structural loads (Table 2) [8].

Table 2.

Main Structural Components of the Combinatorial Modular Mobile Eco-Art Container

Component	Material	Dimension / Specification
Inner container	HDPE polymer	500 × 500 × 150 mm
Outer container	Decorative polymer	500 × 500 × 240 mm
Substrate	Lightweight vegetation substrate	80 mm
Filter layer	Geotextile	2–3 mm
Drainage layer	Expanded clay aggregate (LECA)	40 mm
Plant layer	Succulent plants	30–80 mm
Wheels	Polymer–metal	4 units
LED module	12 V	1 set
Solar panel	Mini PV module	1 unit
Glass top cover	8 mm transparent glass	500 × 500 mm

Methodology for Selecting Succulent Plant Species

In establishing the vegetation layer, xerophytic succulent plant species highly adapted to arid continental climatic conditions were utilized. The selection of plant species was based on the following criteria: (1) presence of the CAM (Crassulacean Acid Metabolism) photosynthetic mechanism; (2) tolerance to water scarcity and drought conditions; (3) shallow root systems ranging from 5–15 cm in depth; (4) minimal structural load imposed on roof constructions; (5) tolerance to high temperatures up to +45°C; (6) resistance to winter temperatures as low as −25°C; (7) adaptability to wind exposure and intense solar radiation; and (8) decorative and aesthetic qualities.

Based on these criteria, the species *Sempervivum tectorum*, *Sedum acre*, *Sedum spurium*, and *Portulaca grandiflora* were selected. These species possess CAM photosynthesis, which minimizes water loss through transpiration and enhances drought resistance. Consequently, they are widely recognized as key succulent species recommended for green roof systems in international practice (Table 3).

Table 3.

Evaluation Matrix for Plant Selection Criteria

№	Plant Species	CAM Photo-synthesis	Drought Tolerance	Shallow Root System	Low Structural	Heat Tolerance	Frost Resistance	Wind & Solar	Decorative Value	Total Score
1	Sempervivum tectorum	5	5	5	5	5	5	5	5	40
2	Sedum acre	5	5	5	5	5	4	5	4	38
3	Sedum spurium	5	4	5	5	4	5	4	5	37
4	Portulaca grandiflora	5	5	5	5	5	2	5	5	37

Note: 5 – Excellent; 4 – Good; 3 – Moderate; 2 – Low; 1 – Very Low.

*Plant Suitability Coefficient.*The suitability of each plant species was evaluated using the following integrated indicator:

$$K_m = \frac{\sum B_i}{n}$$

where: K_m– suitability coefficient; B_i– score assigned for each evaluation criterion;

- n– number of criteria.

The calculated results were as follows: *Sempervivum tectorum*: $K_m = 5.00$; *Sedum* spp.: $K_m = 4.71$; *Portulaca grandiflora*: $K_m = 4.29$.

The results indicate that *Sempervivum* and *Sedum* species are the most suitable vegetation components for the arid continental climate conditions of Samarkand. Their CAM (Crassulacean Acid Metabolism) photosynthetic mechanism and low water consumption make them highly efficient for modular green infrastructure systems. These characteristics can reduce irrigation water demand by approximately 60–80%, thereby enhancing the ecological and economic sustainability of green roof applications [9].

Methodology for Assessing Environmental Efficiency

The environmental efficiency of the proposed combinatorial modular mobile Eco-Art container system was evaluated based on its ability to mitigate the urban heat island effect, improve air quality, conserve water resources, and enhance energy efficiency. The assessment methods were adapted from internationally recognized methodologies used in green roof technologies.

The following key indicators were used in the study:

-Reduction of roof surface temperature (ΔTs);

-Reduction of ambient air temperature (ΔTa);

-Particulate matter retention coefficient (PMR);

-Water saving rate (WSR);

-Energy saving rate (ESR).

Reduction of Roof Surface Temperature

The cooling performance of the vegetation layer was determined using the following equation:

$$\Delta T_s = T_b - T_g$$

where: ΔTs – reduction of roof surface temperature (°C); Tb – temperature of a conventional roof surface (°C); Tg – temperature of a roof surface covered with the modular green system (°C).

Based on calculations and comparative analyses, it was determined that:

$$\Delta T_s = 8 - 12^{\circ}C$$

Reduction of Ambient Air Temperature

The reduction in ambient air temperature was calculated using the following formula:

$$\Delta T_a = T_{a1} - T_{a2}$$

where: Ta1 – air temperature in an area without vegetation; Ta2 – air temperature in an area where the modular vegetation system is installed.

According to the results, a decrease of:

$\Delta T_a = 2 - 4^{\circ}C$ was observed (Table 4) [10].

Table 4.

Environmental Efficiency Indicators

Indicator	Unit of Measurement	Result
Reduction of roof surface temperature	°C	8–12
Reduction of ambient air temperature	°C	2–4
Particulate matter retention	%	10–15
Irrigation water savings	%	60–80

Energy savings	%	15–25
Reduction in maintenance costs	times	2–3

Air Purification Efficiency

The particulate matter retention efficiency of the vegetation layer was evaluated using the following equation:

$$PMR = \frac{M_c}{M_t} \times 100$$

where: PMR – particulate matter retention efficiency (%); Mc – mass of dust retained on the leaf surface; Mt – total mass of atmospheric particulate matter.

The study results revealed that the succulent vegetation cover can retain approximately 10–15% of PM2.5 and PM10 particles.

Irrigation Water Saving Coefficient

The irrigation water saving rate was calculated using the following equation:

$$WSR = \frac{W_t - W_m}{W_t} \times 100$$

where: Wt – water consumption of a conventional landscaping system; Wm – water consumption of the modular succulent system.

The calculations indicated that:

$$WSR = 60 - 80\%$$

Methodology for Assessing Economic Efficiency

The economic efficiency of the system was evaluated based on investment return, energy savings, and reductions in operational and maintenance costs.

The energy-saving rate was determined using the following equation:

$$ESR = \frac{E_b - E_g}{E_b} \times 100$$

where: Eb – energy consumption of a conventional roof structure; Eg – energy consumption when the modular green system is applied.

According to the results: $ESR = 15 - 25\%$

The low maintenance requirements of xerophytic succulent plants resulted in maintenance costs being reduced by approximately 2–3 times compared to conventional flower beds and lawn systems.

Since the proposed design is based on a two-part modular system, manufacturing, transportation, and installation costs were optimized, while the added value of the product increased by approximately 30–40% (Table 5).

Table 5.

Economic Indicators of the Combinatorial Modular Mobile Eco-Art Container.

Indicator	Value
Weight of a single module	26–34 kg
Load per 1 m²	103–136 kg/m²
Water savings	60–80%
Energy savings	15–25%
Reduction in maintenance costs	2–3 times
Added value	30–40%

This methodology enables a comprehensive assessment of the environmental and economic performance of combinatorial modular mobile Eco-Art containers. It also facilitates the identification of the practical benefits of the proposed smart green infrastructure technology in mitigating the urban heat island effect, transforming underutilized rooftops and open spaces into recreational areas, and promoting the efficient use of water and energy resources [11].

Methodology for Assessing Static Load and Structural Safety

This section presents the methodology used to evaluate the static load imposed by the modular system and its compliance with structural safety requirements.

The basic load calculation was determined using the following equation:

$$q = \frac{\sum m_i}{A}$$

where: q – load applied to the roof surface (kg/m²); mi – mass of the individual components of the container (kg); A – occupied area (m²).

The structural safety coefficient was calculated using the following formula:

$$K_s = \frac{Q_{max}}{Q_{mod}}$$

where: Ks – structural safety coefficient; Qmax – maximum allowable load for the roof structure (kg/m²); Qmod – load generated by the modular system (kg/m²).

Assuming: Qmax = 150 kg/m² (recommended limit for extensive green roof systems); Qmod = 120 kg/m² (average calculated load of the proposed system), the safety coefficient is:

$$K_s = \frac{150}{120} = 1.25$$

The obtained result indicates that the proposed modular system satisfies the structural safety requirements and can be safely applied on roof structures designed according to the recommended load standards (Table 6) [6].

Table 6.

Static Load and Structural Safety Assessment Indicators

Indicator	Value
Area of one module	0.25 m²
Weight of one module	26–34 kg
Number of modules per 1 m²	4 units
Total load	103–136 kg/m²
Recommended design load	60–150 kg/m²
Safety coefficient	1.10–1.45

Research Methodology and Statistical Processing

The following scientific methods were employed in the study: system analysis, comparative analysis, landscape planning method, structural modeling, environmental monitoring, economic assessment, and mathematical-statistical calculations.

Environmental and economic indicators were integrated and summarized using the following comprehensive evaluation model:

$$I = \sum_{i=1}^{n} w_i x_i$$

where: I – overall performance index; wi – weighting coefficient of the criterion; xi – normalized value of the indicator.

The weighting coefficients and normalized indicators used in the assessment are presented in (Table 7).

Table 7.

Weighting Coefficients of the Evaluation Criteria.

Criterion	Symbol	Weight Coefficient
Ecological	Ee	0.35
Economic	Ec	0.25
Microclimatic	Em	0.20
Aesthetic	Es	0.20

$$I=0.35Ee+0.25Ec+0.20Em+0.20Es$$

This integrated model enables a comprehensive assessment of the overall performance of the combinatorial modular mobile Eco-Art container system by incorporating ecological, economic, microclimatic, and aesthetic criteria into a single evaluation framework [12].

III. RESULTS AND DISCUSSION

The conducted research and structural calculations revealed the ecological, economic, aesthetic, and microclimatic efficiency of the combinatorial modular mobile Eco-Art container system designed for urban environments, rooftop gardens, and interior spaces. Owing to the mobility and combinatorial characteristics of the developed smart green infrastructure model, the modules can be adapted to various functional areas, rapidly relocated when necessary, and used to transform underutilized rooftops and open spaces into recreational zones.

The static load calculations demonstrated that the total weight of a single module ranges from 26 to 34 kg. When four modules are installed per square meter of roof area, the total structural load amounts to 103–136 kg/m². This value falls within the internationally recommended range of 60–150 kg/m² for extensive green roof systems and represents a significantly lighter structural solution compared to intensive green roof systems. Consequently, the proposed system can be applied on existing accessible rooftops without requiring additional structural reinforcement.

Microclimatic analyses confirmed the positive impact of CAM-photosynthetic succulent species and lightweight vegetation layers on the urban environment. The calculations indicated that the system is capable of reducing roof surface temperatures by 8–12°C and ambient air temperatures by 2–4°C. In addition, the vegetation layer was found to retain approximately 10–15% of airborne PM2.5 and PM10 particulate matter while reducing irrigation water demand by 60–80%. These results demonstrate the potential of the proposed system as a resource-efficient green infrastructure model for cities located in arid continental climatic regions [14,24].

Economic analyses revealed that the modular design optimizes manufacturing, transportation, and installation costs while reducing operational and maintenance expenses by approximately 2–3 times. Due to the thermal insulation properties of the vegetation layer, building energy consumption for cooling and heating can be reduced by 15–25%. Furthermore, the mobile structure and standardized modular system increase the added value of the product by approximately 30–40%.

Another significant advantage identified during the study is related to the aesthetic and cultural identity functions of the system. Decorative exterior modules incorporating imitations of traditional girih and islimi patterns, wood-carving motifs, and glazed-tile ornamentation transform the containers from simple landscaping elements into independent Eco-Art objects reflecting national cultural identity. The integration of LED lighting, solar energy modules, and recreational bench components further enhances the functional capabilities of the system.

Overall, the research findings indicate that the combinatorial modular mobile Eco-Art container system represents a new-generation smart green infrastructure model that is environmentally sustainable, energy-efficient, economically viable, and culturally distinctive for cities located in arid climatic regions. The proposed innovation demonstrates strong potential for practical application in rooftop gardens, public recreational areas, and interior greening projects, contributing to the mitigation of the urban heat island effect and the improvement of urban environmental quality [13,25].

V. IMPLEMENTATION IN PRACTICE

Application Mechanisms in Urban Environments, Rooftop Gardens, Interior Spaces, Public Areas, and Tourism Facilities

The combinatorial modular mobile Eco-Art container system developed through this research represents a smart green infrastructure technology designed to rapidly transform underutilized or insufficiently greened spaces into environmentally sustainable, aesthetically attractive, and functionally efficient environments. The standardized structure, mobile configuration, and multifunctional composition of the modules enable their application across a wide range of urban and architectural settings.

The primary field of application for the proposed system is accessible flat roof structures. By installing the modules on the rooftops of hotels, restaurants, shopping centers, and business complexes, underutilized roof areas can be rapidly transformed into recreational and ecologically active spaces. Structural calculations indicate that the load imposed by the system ranges from 103–136 kg/m², which complies with internationally recommended standards for extensive green roof systems.

A second application area involves parks, boulevards, promenades, pedestrian corridors, and public recreational spaces. The mobile construction allows modules to be quickly rearranged according to seasonal events, festivals, and public gatherings, enabling changes in landscape composition without requiring permanent construction interventions [18, 20].

The system can also be effectively implemented within educational and healthcare facilities. In kindergartens, schools, universities, hospitals, and sanatoriums, modular greening elements contribute to the creation of healthy microclimatic conditions, the organization of recreational spaces, and the promotion of environmental education and awareness.

Implementation is equally appropriate in industrial zones and around manufacturing facilities. The modules can be used to establish temporary rest areas, pedestrian pathways, and green buffer zones, thereby improving the environmental quality and aesthetic appearance of industrial environments.

Furthermore, the system has been adapted for residential courtyards, accessible rooftops of multi-story residential buildings, and balconies. Owing to the mobile nature of the design, users can independently modify landscape compositions according to seasonal requirements or changing functional needs.

Another promising field of application is interior space design. In atriums, foyers, winter gardens, enclosed public halls, and shopping malls, the modules can be utilized to create environmentally beneficial and visually attractive green compositions. The low-maintenance requirements of xerophytic succulent plants, combined with integrated LED lighting systems, ensure long-term functionality and sustainability within indoor environments.

In addition, the decorative exterior panels featuring imitations of traditional girih and islimi patterns, wood-carving motifs, and glazed-tile ornamentation allow the modules to function as Eco-Art objects reflecting national cultural identity. This characteristic makes them particularly suitable for application in historic city centers, tourism destinations, museums, and cultural heritage sites.

Overall, the developed combinatorial modular mobile Eco-Art container system is recommended as an innovative smart green infrastructure model with universal applicability in rooftop gardens, public recreational areas, educational and healthcare institutions, industrial zones, residential complexes, interior spaces, and tourism facilities (Figure 2) [17, 22].

a b

Figure 2. Combinatorial Modular Mobile Eco-Art Container System and Xerophytic Landscape Elements for Urban Environments, Rooftop Gardens, and Interior Spaces:

a) Polymer-structured combinatorial modular mobile Eco-Art container with decorative glazed-tile ornamentation in an Islimi pattern style; b) Polymer-structured combinatorial modular mobile Eco-Art container with Girih pattern-style wood-carving imitation decorative finish.

VI. CONCLUSION

As a result of the conducted research, a new conceptual model of a combinatorial modular mobile Eco-Art container system and xerophytic landscape elements designed to enhance the environmental quality of urban environments, rooftop gardens, and interior spaces was developed, and its scientific and practical effectiveness was substantiated. By integrating green infrastructure, Nature-Based Solutions (NbS), smart technologies, and elements of traditional national decorative arts into a unified system, an innovative landscape solution for cities located in arid climatic regions was proposed.

The research findings demonstrated that a single element of the two-part polymer modular system has a total weight ranging from 26 to 34 kg. When four modules are installed per square meter, the resulting structural load on the roof surface ranges from 103 to 136 kg/m². Since this value corresponds to the internationally recommended load range for extensive green roof systems, it was confirmed that the proposed system can be applied to the accessible rooftops of most existing buildings and structures without requiring additional structural reinforcement.

The use of xerophytic succulent plant species possessing CAM (Crassulacean Acid Metabolism) photosynthesis was found to be highly effective in improving the environmental quality of urban areas. Calculations and comparative analyses demonstrated that the system is capable of reducing roof surface temperatures by 8–12°C and ambient air temperatures by 2–4°C, while retaining approximately 10–15% of airborne PM2.5 and PM10 particulate matter. Furthermore, the system can reduce irrigation water demand by 60–80% and decrease building energy consumption for cooling and heating by 15–25%, thereby contributing significantly to environmental sustainability and resource efficiency.

One of the most important scientific outcomes of the research is the integration of mobile modular structures, smart technologies (LED lighting and solar energy modules), xerophytic landscape elements, and national decorative art motifs based on Girih and Islimi patterns into a single combinatorial system. This approach enables the containers to function not merely as landscaping elements but as independent Eco-Art objects that simultaneously perform ecological, functional, and aesthetic roles.

From a practical perspective, the developed system is recommended as a universal smart green infrastructure model for application in rooftop gardens, public recreational areas, educational and healthcare institutions, industrial zones, residential complexes, interior spaces, and tourism facilities. The mobile and combinatorial characteristics of the modules enable the rapid transformation of underutilized spaces into ecologically active environments, enrich the visual quality of urban landscapes, and harmoniously combine national cultural identity with contemporary landscape architecture.

In conclusion, the developed "Combinatorial Modular Mobile Eco-Art Container System and Xerophytic Landscape Elements" can be regarded as a new-generation smart green infrastructure technology that is environmentally sustainable, energy-efficient, economically viable, and culturally distinctive for cities located in arid climatic regions, particularly for the microclimatic conditions of Samarkand. Therefore, its broad implementation in contemporary urban development and landscape design practices is considered both appropriate and highly promising.

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