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MAIN PRINCIPLES AND APPROACHES TO THE FORMATION OF LANDSCAPE DESIGN IN THE REPUBLIC OF KARAKALPAKSTAN

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Abstract
This article is dedicated to the formation of sustainable landscape design principles in the arid climate conditions of the Republic of Karakalpakstan. The study analyzes local plant species, water-saving technologies, and the principles of adapting international experience to regional conditions. Additionally, recommendations have been developed to reduce soil erosion, improve the microclimate, and enhance urban green spaces through green walls and ecological infrastructure. This article proposes approaches aimed at restoring ecological balance and ensuring urban development.

Keywords: *Karakalpakstan, landscape design, water-saving technologies, green walls, ecological infrastructure, international practices, arid climate.*

Introduction

The Republic of Karakalpakstan, located in the northwestern region of Uzbekistan, is distinguished by its unique climatic and ecological characteristics [1]. The region is predominantly characterized by an arid and desert climate, which significantly impacts its ecological and urban development. In recent years, the processes of desertification have intensified under the influence of global climate change, and water resource shortages have become a critical issue in the region. In particular, the ecological crisis caused by the drying up of the Aral Sea has severely disrupted the natural balance of the area. Therefore, ensuring sustainable development through urban landscape design in the climatic conditions of Karakalpakstan is one of the urgent tasks [2].

The significance of landscape design is increasingly growing worldwide. Research indicates that green infrastructure not only provides aesthetic and recreational opportunities for urban populations but also plays a crucial role in ensuring ecological sustainability. Specifically, green spaces act as carbon dioxide absorbers, improve air and soil quality, reduce wind erosion, and regulate the microclimate. These features are even more relevant for regions with arid climates. In areas like Karakalpakstan, enhancing urban ecological resilience through green infrastructure, water-saving technologies, and climate-adapted plant species is essential [3].

Landscape design has historically played a significant role in urban planning. Concepts such as the "urban park," which emerged in the mid-19th century, further emphasized the importance of green infrastructure in urban environments [3]. Today, these principles are widely recognized globally and are regarded as key tools for achieving ecological sustainability. Studying these

principles and international experiences is of great importance in developing landscape design solutions adapted to Karakalpakstan.

This article focuses on developing landscape design principles suited to the natural and socio-economic conditions of Karakalpakstan. It explores innovative approaches to creating ecologically sustainable green spaces in the region, including water-saving technologies and the use of native plant species. Additionally, recommendations are provided on adapting international experiences to the specific conditions of Karakalpakstan for the development of climate-resilient green infrastructure.

Methodology. This study focuses on developing sustainable landscape design principles for the arid climate conditions of Karakalpakstan. Nukus city was selected as the study area, and its climatic and ecological characteristics were analyzed. Data on the region's natural resources, desertification processes, and the state of green spaces were collected to identify the region's ecological and urban challenges. Key solutions, such as the use of native plant species and water-saving technologies, were examined, employing scientific approaches.

Additionally, successful international landscape design practices in arid climates were analyzed. During the research, recommendations were developed for utilizing climate-adapted plants, efficiently organizing green spaces, and creating ecologically sustainable infrastructure. These principles contribute to reducing wind erosion, improving the microclimate, and enhancing the overall livability of the environment.

Results. According to the research findings, the following key principles and practical approaches were identified for implementing sustainable landscape design in the arid climate conditions of Karakalpakstan:

- Plant species adapted to the climate and ecological conditions of Karakalpakstan: Plant species suitable for the region's arid and desert climate conditions were identified. Among these, representatives of the local flora were noted as the most optimal choice for forming ecologically sustainable green areas to combat desertification and reduce wind erosion. These plants are distinguished not only by their low water requirements but also by their ability to protect soil from erosion and reduce wind intensity.
- Application of water-saving technologies: Efficient management of resources for supplying urban green spaces with water is crucial for Karakalpakstan. The study identified the following advanced water-saving technologies as effective:

Drip and sprinkler irrigation systems: One of the most effective solutions for conserving water for local flora and specially selected plant species, delivering water directly to root zones [2].

Solar-powered automated irrigation systems: These systems improve energy efficiency and ensure long-term ecological sustainability [5].

- Green walls to reduce wind erosion. To mitigate wind erosion, prevent soil degradation, and improve the microclimate in Karakalpakstan, the creation of green walls was proposed. Green walls protect soil from wind and help regulate wind direction, contributing to the stabilization of agricultural and urban areas [4].
- Ecologically sustainable green infrastructure. The following principles were established to enhance the ecological value of green spaces in the region:

Dividing green zones into functional sections (recreational, ecological, decorative zones) and integrating them into an interconnected system.

Utilizing vertical gardens and other innovative design elements, which expand urban green spaces [5].

- Adaptation of international experiences to local conditions. International practices in green space development under arid climate conditions were studied, and beneficial aspects were

adapted to the regional context. For example, water-saving technologies used in Middle Eastern countries and the experience of utilizing climate-adapted plants in Central Asia could serve as successful models for Karakalpakstan [3].

The main principles and approaches to landscape design in the context of Karakalpakstan

Principles/Approaches	Practical application	Expected result
Local flora selection	Selection of plants such as saxaul, saxaul, desert yellow	Reducing soil erosion, ensuring climate resilience
Water saving technologies	Drip irrigation, solar energy use	Effective use of water resources, increasing the sustainability of green areas
Green Walls and Vertical Gardens	Creating green walls against wind erosion	Microclimate improvement, soil preservation
Customize international experience	Implementation of Central Asian Calling Technologies	Create sustainable infrastructure suitable for dry areas
Functional division of green areas	Creation of recreational, ecological and decorative zones	Improving social infrastructure, improving the quality of life of the population

Discussion. The research findings identified several key principles and practical approaches for developing sustainable landscape design in the climatic conditions of Karakalpakstan. The scientific and practical significance of the results, their alignment with international experience, and their adaptability to regional conditions were thoroughly analyzed.

Ecological and economic importance of local plants. In Karakalpakstan's arid climate and conditions of water scarcity, local flora species are essential not only for ensuring ecological sustainability but also for increasing economic efficiency. The study confirmed that local plants play a role in protecting soil from wind erosion, improving the microclimate, and acting as carbon sinks. This approach aligns with successful practices implemented in arid regions of the Middle East and Central Asia [5].

The importance of water-saving technologies. Limited water resources in Karakalpakstan pose one of the greatest challenges for landscape design development. Drip irrigation systems and solar-powered automated irrigation technologies were identified as effective solutions for conserving water and ensuring the sustainability of green areas. These technologies have been successfully applied in irrigation systems in Middle Eastern countries and can be adapted to the conditions of Karakalpakstan.

Green walls and wind erosion reduction. The study revealed that the establishment of green walls and dense green areas plays a crucial role in preventing wind erosion. This approach slows down desertification processes in the region. China's "Green Wall" project and other international experiences confirm the effectiveness of this method in combating wind erosion. In Karakalpakstan, this strategy can help improve soil fertility and support agricultural activities.

Adapting international experiences. International landscape technologies successfully used in arid climates can also benefit Karakalpakstan. The achievements of Israel, Australia, and Central Asian countries in drip irrigation, zoning green spaces, and creating ecologically sustainable infrastructure should be adapted to regional conditions. In this adaptation process, local climate, available resources, and cultural specificities must be considered.

Figure 1. A green wall constructed along an asphalt road in the Takla-Makon Desert of China, based on drip irrigation and drip irrigation. This regulated fight against desertification and wind erosion was carried out by the enterprise

Among the key issues identified during the study were the insufficient availability of water resources and the ecological degradation of arid areas [1]. Additionally, the limited scientific data on local flora and the lack of economic opportunities for implementing ecological approaches were recognized as major constraints. To overcome these challenges, it is necessary to expand international cooperation and introduce advanced technologies.

Conclusion. The climatic and ecological conditions of Karakalpakstan, particularly the limited water resources and desertification processes, highlight the urgent need for sustainable landscape design. This study has demonstrated that selecting native plant species, utilizing water-saving technologies, and adapting international experiences are the key principles for developing green infrastructure in the region.

The research findings indicate that the use of local plant species plays a crucial role in restoring ecological balance and ensuring the sustainability of green spaces. Species such as Salix alba, Fraxinus excelsior, and other drought-resistant plants significantly contribute to reducing wind erosion and improving soil quality. Water-saving technologies, such as drip irrigation and solar-powered automated systems, enable the efficient use of water resources, helping to address the region's ecological challenges.

The implementation of green walls and vertical gardens in urban areas can mitigate the adverse effects of climate change. These methods not only enhance ecological efficiency but also contribute to the aesthetic improvement of cities.

Recommendations. A set of recommendations has been developed for the improvement of green spaces in Karakalpakstan. These recommendations include the widespread use of native plant species, the large-scale implementation of water-saving technologies, and the functional zoning of green areas based on ecological principles for recreational, decorative, and environmental

purposes. Additionally, the introduction of scientific research and monitoring systems, as well as the development of strategic approaches to ensure ecological sustainability in the region, is advised.

- Utilization of native flora and plant species: It is necessary to expand the use of plant species adapted to the conditions of Karakalpakstan and integrate them into ecological parks and green infrastructure.
- Implementation of water-saving technologies: The expansion of drip irrigation, automated irrigation systems, and the use of solar energy can help mitigate water scarcity in the region.
- Creation of green walls and vertical gardens: To reduce wind erosion and improve the microclimate, it is recommended to introduce green walls and vertical gardens in both urban and rural areas.
- Adaptation of international experiences: Studying successful landscape design practices from arid regions such as Israel, Australia, and Central Asia and adapting them to Karakalpakstan's conditions is crucial.

Establishment of research and monitoring systems: Setting up scientific research centers to continuously monitor the state of green infrastructure, study the impact of climate change, and develop sustainable development strategies is essential.

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