FOREIGN EXPERIENCE AND INNOVATIVE PROPOSALS FOR LANDSCAPING IN TERRITORIES WITH EXTREME CLIMATIC CONDITIONS OF KARAKALPAKSTAN

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Abstract: The aim of this research is to study innovative foreign and local experiences in greening areas considered climatically unfavorable for plant cultivation in Uzbekistan. Based on this, the study seeks to develop proposals and recommendations for greening desert regions and settlements in the Aral Sea region and improving their ecological conditions. The article explores practices of plant cultivation and landscaping in areas characterized by extensive sand and desert terrain, with particular focus on experiences from China and Egypt—especially the creation of the Serapium forests in the Egyptian deserts. It further proposes how these experiences can be applied in Uzbekistan's challenging regions, such as saline and desert soils in the Aral Sea area, including settlements. The study also offers suggestions on using wastewater (sewage) for afforestation, controlling sand drifts, and implementing effective landscaping in these inhospitable conditions.

Keywords: Karakalpakstan, Aral Sea region, climatically unfavorable areas for plant growth, landscaping activities, Uzbekistan and foreign countries, Egypt, China experiences.

Introduction: A significant part of Uzbekistan consists of regions with unfavorable conditions for plant growth—characterized by hot and dry summers, cold winters, saline soils, and desert landscapes. In such areas, it is particularly difficult and challenging to preserve flora and fauna, combat erosion, and carry out greening efforts in settlements. Among the foremost regions facing these issues are the Republic of Karakalpakstan, the Aral Sea zone, and the northwestern areas of Karakalpakstan, where settlements are located. The landscape and natural environment of this region have undergone severe erosion and degradation as a result of the reduced flow of the Amu Darya River and the gradual drying up of the Aral Sea.

Although the government of Uzbekistan and the international community have undertaken systematic efforts to mitigate and eliminate the negative consequences of this situation (such as planting saxaul trees in the saline lands of the dried Aral Sea bed, or growing the Indigofera plant with the help of scientists from the Tashkent Institute of Agriculture) [1; 6], revitalizing the

landscape and environment of the region, as well as greening the surrounding areas and settlements, remains a pressing and strategically important issue at the national level.

Accordingly, this research is dedicated to studying global practices aimed at improving the ecological environment and climatic conditions of desert zones with unfavorable conditions for plant cultivation, and applying these experiences to the greening of settlements located in the Aral Sea region of Karakalpakstan. Local scholars such as A.S. Uralov, A.N. Gadayev, and B.Yu. Kidirboev have addressed this issue [4]. However, broader innovative scientific approaches based on international experience have not yet been implemented to solve the problem effectively.

The research methodology is based on a comprehensive scientific approach to the problem and includes the following specific research methods:
– analysis through comparison of materials collected from scientific and specialized literature, project documentation, and regulatory documents related to the issue;

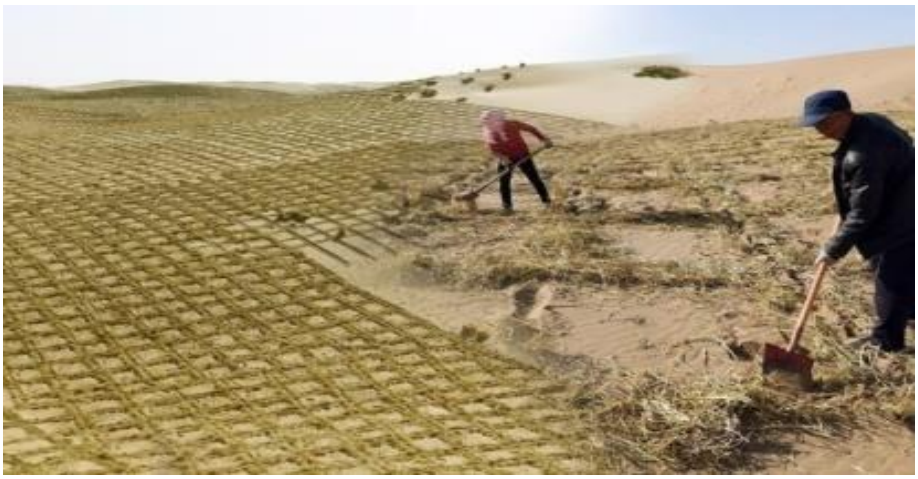
– and the development of new proposals and recommendations for greening urban areas located in hot and arid climate zones.

Research Results. It is well known that the Aral Sea region of Karakalpakstan, located within the Republic of Uzbekistan, is considered one of the most unfavorable areas for plant cultivation and maintenance. This is due to the region's natural climatic and soil conditions, which pose significant challenges in forming sustainable vegetation. In order to effectively grow plants and carry out greening activities in settlements in these areas, it is necessary to lower the groundwater level and carry out soil leaching activities during the winter to reduce salinity. These measures require substantial financial investment.

In addressing this issue, studying the experiences of foreign countries that possess similar desert landscapes to the Aral Sea region is of great importance. We examined solutions to the problem using examples from the People's Republic of China and the Arab Republic of Egypt in Africa. Specifically, China has implemented a national program to combat the desertification of grassland areas used for agriculture [5]. This program includes measures to halt sand movement caused by strong desert winds that threaten fields and settlements, grow vegetation capable of stabilizing desert soils, and thus improve the ecological state of villages and towns located in desert and steppe regions. It also

includes the creation of jobs for the local population [5]. The following images (Figures 1 and 2) partially reflect the implementation of this program.

1 – figure



2 – figure

In African countries, halting the movement of desert sands is also considered a serious issue. Egypt has implemented a unique and effective method to address this problem—namely, afforesting desert areas. However, in regions where rainfall is minimal or natural water sources are nearly absent, how can one grow trees, let alone forests? Scientists have devised an excellent solution to this challenge. One of the best examples of its effectiveness is the artificially created **Serapium Forest** in the Egyptian desert. The Serapium Forest was established in the desert region of Egypt and is irrigated using treated wastewater (sewage) [1]. Egyptian scientists, in an effort to prevent sand movement and create a favorable ecological environment in the desert, began treating wastewater from Cairo and other cities across Egypt and using it to irrigate and cultivate artificial forests [2]. By using wastewater for irrigation, they have managed to transform desert and arid areas into forest zones and promote the growth of rare tree species such as **eucalyptus** and **redwood**,

thereby significantly improving the region's ecological environment and climatic conditions.

Since the 1990s, more than **200 hectares** of decorative trees have been planted in Egypt [3]. This extraordinary forest continues to flourish in the Egyptian desert to this day. The Serapium Forest is indeed an **innovative project** resulting from the collaboration between **Egyptian and German scientists**. Below (Figures 3–7) are examples and general views of the outcomes achieved through the implementation of this project.

3 – figure

4 – figure

5 – figure

6 – figure

7 – figure

The project is not based on expectations of natural rainfall or water reserves but relies on a specially adapted **wastewater (sewage water) irrigation system**. In this method, trees are provided not only with **moisture** but also with essential **nutrients**, which significantly support plant growth [1].

The wastewater used for irrigation undergoes a **two-stage purification process**: **Mechanical filtration**, and **Biological treatment and oxygen enrichment**. Treated in this way, the wastewater becomes rich in **phosphates** and **nitrogen**, turning it into a highly effective fertilizer when used in irrigation systems for crops and forest plantations [2].

Although the wastewater used for irrigation is subjected to purification, this method is applied **only for the cultivation of non-edible ornamental trees and plants**. This **alternative approach is considered ideal for the conditions in Egypt**, as moisture in the form of treated wastewater is delivered directly to the forest through a system of pipelines and hoses that cover hundreds of hectares of sandy desert, originating from the treatment plant (see Figures 8–9).

8 – figure

According to the project authors, "**Trees in Serapium grow four times faster than those in Germany. If 80% of Egypt's wastewater were utilized, it would be possible to turn 650,000 hectares of desert into forest**," they write [1;2] (Figure 6).

As for the **Aral Sea region**, this method could potentially be applied in the **desert, sandy, and steppe areas surrounding the city of Nukus**. The **wastewater (sewage) discharged from Nukus** could be treated and used within this system. Given the **expected population growth in Nukus** and the **presence of existing wastewater treatment facilities** on the outskirts of the city, it is feasible to **transform the desertified lands around Nukus**, as well as

the **desert areas surrounding the city of Muynak in the Aral Sea region**, into forests using the **Egyptian approach**, thereby **improving the region's ecology**.

9-figure

Wastewater from Takhiatash and other cities located near desert areas can also be included in this system. The use of treated wastewater for irrigating non-fruit-bearing, ornamental trees and crops is considered appropriate for greening the desert areas of the Aral Sea region based on the following factors:

- It prevents the spread of sand particles into the surrounding environment;
- The establishment of tree and crop plantations improves the ecological condition of the environment;
- Economic enterprises can be created for maintaining and utilizing these plantations, which will result in the creation of new jobs;
- The improvement of the landscape will enable the development of other engineering infrastructure;

Treated, non-polluting wastewater will support irrigation systems and help form a stable microclimate. When applying these proposals in practice, strict compliance with sanitary-epidemiological regulations must be ensured, especially regarding the use of treated wastewater for irrigation in hot and arid desert zones.

If it is not possible to improve the soil for planting vegetation, the most appropriate approach is to **select plant species that are naturally suited to the existing soil conditions**. In this regard, the following plant species are recommended for **saline soils**: *Ailantus, Caspian gleditsia, Amorpha, Fluffy sumac, Tamarix (grebenshchik), Indigofera* (see Figures 10–11).

For **sandy soils**, it is recommended to plant species from the group of so-called **"psammophytes"** (plants adapted to sandy environments). These include: *Ailantus, Warty birch (Betula pendula), Purple and Caspian willow (Salix purpurea and Salix caspica), Ash-leaved and Silver and Tatar maples (Acer negundo, A. saccharinum, A. tataricum), Pine (Pinus spp.), Narrow-leaved and Silver oleaster (Elaeagnus angustifolia and E. commutata), White and Canadian poplar (Populus alba and P. canadensis), Golden currant (Ribes aureum), Yellow acacia (Caragana arborescens), Meadowsweet (Spiraea spp.), and Snowberry (Symphoricarpos spp.).

10-figure

11-figure

In addition to the aforementioned measures, we also recommend using **decorative shrubs and flowering plants grown in containers and pots**, as well as **artificial turf coverings** for landscaping the settlements located in the **Aral Sea region**. Moreover, the use of **hydroponic and hydroseeding methods** for plant cultivation is also advised (see Figures 12–16).

12-figure

13-figure

14-figure

15-figure

16-figure

Scientific research in this area is currently being carried out in cooperation between scientists from the **Samarkand State Institute of Architecture and Construction** and **Karakalpak State University**. These scientific studies focus on the practical application of the developed proposals, their **technical and economic justification**, and **adaptation to the specific climatic conditions** of the region—in other words, their ongoing improvement and refinement.

Discussion. The cities of **Nukus, Muynak, Navoi, Karmana, Zarafshan, Konimekh, Muborak**, and other urban areas in Uzbekistan with similar **geographical features dominated by deserts and arid lands**, can potentially benefit from using **treated wastewater**. By doing so, it is possible to **improve the ecological environment and climate conditions** of the surrounding desert landscapes in these regions. Applying the same method at the local level by utilizing wastewater from settlements such as **district centers, towns, and sanatoriums** is also of great significance. In particular, the **experience of using**

wastewater from **the town of Muborak and its industrial zone in the Kashkadarya region**, as well as from the **Akkurgan Sanatorium in Surkhandarya**, has already been implemented. To **revitalize desert landscapes** under extreme climatic conditions, it is essential to **scale up the use of such foreign and local ecological methods**. To achieve this, **attracting scientists and investors from countries like Egypt, Germany, and China**, which have extensive experience in this field, could lay the foundation for **solving major economic and environmental challenges** of national importance in Uzbekistan.

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