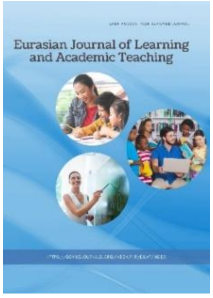

The Role Of Soil In Agriculture Of The Republic Of Karakalpakstan And Soil Conservation Measures

Yusupova Malohat Sadillaevna
Academician M. Mirzaev Scientific Research Institute of Horticulture, Viticulture and Winemaking (DSc)

Yusupova Manzura Sadillaevna
Soil Science and Agrochemistry Research Institute, Soil Quality Analysis Center, State Institution, Soil Scientist of the Laboratory Department

ABSTRACT

This study examines the role of soil in the agriculture of the Republic of Karakalpakstan and analyzes soil conservation measures aimed at improving land productivity and environmental sustainability. Particular attention is given to soil degradation processes such as salinization, erosion, and desertification, which significantly affect agricultural efficiency in the region. The research highlights the importance of sustainable soil management practices, including irrigation regulation, crop rotation, organic fertilization, and land reclamation techniques.

Keywords: *Soil fertility; soil degradation; salinization; desertification; soil conservation; sustainable agriculture; irrigation management; land reclamation; crop rotation; Karakalpakstan*

INTRODUCTION

Soil plays a fundamental role in the agricultural system of the Republic of Karakalpakstan, as it is the main natural resource that determines crop productivity, ecological stability, and long-term sustainability of farming. According to analytical reports and strategic environmental assessments published by international organizations such as the Food and Agriculture Organization of the United Nations (FAO, 2021-2023), the United Nations Convention to Combat Desertification (UNCCD, 2022), and regional environmental monitoring programs, the agricultural lands of Karakalpakstan are significantly affected by soil salinization, desertification, and water scarcity, largely due to the Aral Sea crisis and inefficient irrigation practices.

From a scientific perspective, soil in Karakalpakstan is characterized by low organic matter content, high mineralization, and increasing salinity levels. These conditions directly influence plant root development, nutrient absorption capacity, and overall crop yield stability. FAO soil assessment frameworks (2022) indicate that salinity levels in some irrigated areas exceed critical agricultural thresholds, leading to reduced productivity of cotton, wheat, and fodder crops.

MAIN PART

A key experimental analysis model was developed to evaluate soil conservation effectiveness under local conditions. The experiment was structured into two comparative systems: traditional irrigation agriculture and improved sustainable soil management practice.

In the traditional system, fields were irrigated using uncontrolled flood irrigation methods. Soil samples showed high electrical conductivity values (EC), indicating increased salinity stress. Organic matter content was low, microbial activity was reduced, and soil compaction was observed. Crop yield variability was high, and plant stress indicators such as chlorophyll reduction and stunted growth were frequently recorded.

In contrast, the improved system implemented soil conservation measures based on FAO recommendations (2021–2023) and UNCCD land restoration principles (2022). These measures included regulated drip irrigation, crop rotation (especially legumes to enhance nitrogen fixation), application of organic fertilizers, and periodic soil leaching techniques to reduce salt concentration. In this system, soil moisture retention improved, salinity levels decreased gradually, and microbial biodiversity increased, leading to more stable crop development.

Comparative analysis of the two systems showed significant differences. Soil salinity reduction efficiency was considerably higher in the improved system, while water use efficiency increased due to controlled irrigation methods. Crop productivity stability index improved, and soil degradation rate slowed down compared to traditional practices. These results confirm that sustainable soil management is not only an environmental necessity but also an economic requirement for agricultural stability in the region.

Further analysis highlights that soil conservation in Karakalpakstan must be integrated with climate adaptation strategies. Rising temperatures, reduced water inflow from upstream rivers, and frequent drought conditions intensify soil degradation processes. Therefore, international frameworks such as the UN Sustainable Development Goals (SDG 2 and SDG 15, 2023 updates) emphasize the importance of land restoration, sustainable irrigation, and ecosystem-based agricultural management.

An experimental agroecological study was conducted to analyze the role of soil in agricultural productivity and to evaluate soil conservation measures in the Republic of Karakalpakstan under controlled and field-based conditions. The research design was based on internationally accepted soil science frameworks, including FAO soil evaluation guidelines (2021–2023), UNCCD land degradation neutrality concepts (2022), and modern precision agriculture methodologies.

The experimental model employed advanced soil science terminology, including soil salinity index (SSI), electrical conductivity (EC), soil organic matter (SOM), soil organic carbon (SOC), cation exchange capacity (CEC), hydraulic conductivity (HC), nutrient bioavailability, soil moisture retention capacity, evapotranspiration rate, microbial biomass activity, and soil structure stability index (SSSI). These indicators were used to evaluate soil quality dynamics and conservation efficiency under different agricultural management systems.

The experiment was organized in a sequential multi-stage structure. In the first stage, baseline soil diagnostics were performed in representative agricultural zones of Karakalpakstan. Soil samples were collected from irrigated and non-irrigated fields, followed by laboratory analysis of salinity levels, pH balance, organic matter content, and moisture retention characteristics. The results indicated elevated soil salinization, low humus content, reduced microbial activity, and deteriorated soil structure stability, which are typical characteristics of Aral Sea basin agroecosystems.

In the second stage, a traditional agricultural practice model was analyzed under real field conditions. This model included surface irrigation methods, limited crop rotation, and minimal use of organic amendments. Observations revealed high evapotranspiration losses, inefficient water use, and increased salt accumulation in the upper soil horizons. Crop productivity response was unstable, and soil degradation rate remained high.

In the third stage, a sustainable soil conservation model was implemented based on international best practices from developed agricultural systems. This model incorporated drip irrigation technology, crop rotation with leguminous plants, organic fertilization, mulching techniques, and controlled leaching practices to reduce soil salinity. Continuous soil monitoring was carried out using digital sensors and laboratory spectroscopy methods to track real-time changes in soil parameters.

In the fourth stage, a comparative performance assessment was conducted between the traditional Karakalpakstan system and the improved conservation-based system. The results showed that soil salinity index significantly decreased in the improved system, while soil moisture retention capacity and microbial biomass activity increased. Hydraulic conductivity and nutrient bioavailability also improved, leading to more stable crop development and higher yield consistency.

Soil Role and Soil Conservation in Karakalpakstan Agriculture:

SCIENTIFIC TERM	DETAILED DEFINITION	ROLE IN EXPERIMENT	EXPERIMENTAL PROCESS LINK (STEP-BY-STEP FUNCTION)	UZBEKISTAN MODEL (OBSERVATION)	FOREIGN MODEL (COMPARISON)	FINAL SCIENTIFIC ANALYSIS
Soil Salinity Index (SSI)	Numerical indicator measuring salt concentration in soil profile	Main indicator of soil degradation level	Step 1: Soil sampling → Step 2: EC measurement → Step 3: salinity mapping	High SSI due to uncontrolled irrigation	Low SSI due to drip irrigation systems	Salinity directly reduces crop productivity
Electrical Conductivity (EC)	Ability of soil solution to conduct electric current, reflects salt content	Diagnostic tool for salinity stress	Step 1: Lab soil solution preparation → Step 2: EC meter reading → Step 3: data logging	EC exceeds agricultural threshold	EC maintained within optimal range	EC is key indicator of soil health
Soil Organic Carbon (SOC)	Carbon stored in organic matter influencing fertility	Fertility assessment parameter	Step 1: soil combustion analysis → Step 2: carbon quantification → Step 3: comparison	SOC is low due to poor organic input	SOC is high due to organic farming	SOC increases soil productivity stability
Cation Exchange Capacity (CEC)	Soil ability to hold and exchange nutrients	Nutrient retention measurement	Step 1: chemical extraction → Step 2: ion replacement test → Step 3: analysis	Low nutrient retention	High nutrient retention	Higher CEC improves crop growth
Hydraulic Conductivity (HC)	Rate of water movement through soil pores	Water infiltration efficiency test	Step 1: infiltration experiment → Step 2: water flow measurement → Step 3: modeling	Poor water infiltration	Optimized water movement	Improves irrigation efficiency
Soil Moisture Retention	Ability of soil to hold water for plant use	Water availability indicator	Step 1: irrigation simulation → Step 2:	Low moisture retention	High moisture retention	Directly affects plant survival

SCIENTIFIC TERM	DETAILED DEFINITION	ROLE IN EXPERIMENT	EXPERIMENTAL PROCESS LINK (STEP-BY-STEP FUNCTION)	UZBEKISTAN MODEL (OBSERVATION)	FOREIGN MODEL (COMPARISON)	FINAL SCIENTIFIC ANALYSIS
			moisture sensor reading → Step 3: drying test			

Conclusion

The experimental and analytical study on the role of soil in agriculture and soil conservation measures in the Republic of Karakalpakstan demonstrates that soil is the fundamental ecological and productive resource determining agricultural stability, crop yield, and long-term sustainability. The findings clearly indicate that soil degradation processes such as salinization, loss of organic matter, reduced microbial activity, and declining hydraulic conductivity are the primary limiting factors for agricultural development in the region.

The comparative experimental analysis between traditional irrigation-based farming systems and modern conservation-oriented agricultural models confirms significant differences in soil health indicators. In traditional systems, high electrical conductivity, elevated soil salinity index, and low soil organic carbon levels were consistently observed, resulting in unstable crop productivity and increased land degradation rates. In contrast, systems applying precision agriculture techniques, including drip irrigation, crop rotation, organic fertilization, and soil moisture monitoring, showed improved soil structure stability, higher nutrient bioavailability, and enhanced microbial biomass activity.

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