



SOILS AND AGROCLIMATIC CONDITIONS OF THE BUKHARA REGION, REPUBLIC OF UZBEKISTAN

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Abstract. *The article examines the soil-climatic and agromeliorative characteristics of the Bukhara region of the Republic of Uzbekistan, located in the subtropical desert zone of Central Asia. Based on long-term meteorological observations, the temperature regime, precipitation amount, moisture evaporation, wind processes, and their influence on agricultural crop development are analyzed. Particular attention is paid to the characteristics of irrigated meadow, meadow-bog, meadow-takyr, and grey-brown soils, including their mechanical composition, salinity level, and nutrient availability. It is shown that high evaporation rates, low air humidity, and shallow groundwater levels contribute to the development of salinization processes. The necessity of efficient operation of the collector-drainage network and rational water use for maintaining soil fertility in the region is substantiated.*

Keywords: *agroclimate, irrigated soils, meadow soils, salinity, groundwater, land reclamation, desert agriculture, soil fertility.*

1. INTRODUCTION

The Bukhara region of the Republic of Uzbekistan belongs to areas with a sharply continental and arid climate, where agricultural development is closely associated with irrigated farming. The agroclimatic conditions of the region are characterized by high air temperatures, low amounts of atmospheric precipitation, and significant moisture evaporation, which substantially influence soil-forming processes and land productivity. Under the conditions of a subtropical desert zone, irrigation systems

and meliorative measures aimed at regulating the water–salt regime of soils play a particularly important role.

The soil cover of the region is highly diverse and includes hydromorphic, automorphic, and transitional soil types formed on alluvial and deluvial–proluvial deposits. Among them, irrigated meadow soils are the most widespread, possessing relatively high productivity but being prone to salinization due to intense evaporation and rising groundwater levels. Therefore, studying the soil and agroclimatic



characteristics of the region is essential for improving land-use efficiency and ensuring the sustainable development of the agricultural sector.

2. Materials and Methods

The research materials included long-term meteorological observation data from the “Bukhara” and “Karakul” stations, as well as the results of soil-meliorative surveys conducted across the Bukhara region. The study utilized information on air temperature regime, atmospheric precipitation, relative humidity, moisture evaporation, and the regional wind regime. In addition, indicators such as soil mechanical composition, humus content, nitrogen levels, available forms of phosphorus and potassium, degree of salinity, and groundwater occurrence were analyzed.

The research was carried out using comparative-geographical, morphogenetic, and agrochemical methods. Statistical analysis of long-term climatic data was applied to assess agroclimatic conditions. Soil characteristics were determined through the generalization of soil survey materials and analysis of scientific literature sources. A systems approach was used to evaluate the meliorative condition of lands, allowing the identification of relationships between the water-salt regime, irrigation conditions, and the productivity of the soil cover.

3. Results and Discussion

The irrigated zone of the Bukhara region is located within the desert zone.

According to long-term data from the “Bukhara” and “Karakul” meteorological stations, the average annual air temperature ranges from 14.8 to 15.1 °C. The temperature of the hottest month (July) reaches 29.1–29.6 °C, while that of the coldest month (January) ranges from –0.4 to –0.6 °C. The average monthly air temperature during the vegetation period (April–September) is 23.3–24.3 °C.

Positive air temperatures become established at the end of February, and in early March the average daily temperature steadily rises above +5 °C, initiating the vegetation period of grasses, cereals, and fruit crops. By late March–early April, average daily temperatures exceed +10 °C, creating favorable conditions for sowing heat-loving crops. The frost-free period lasts 213–215 days. The sum of effective temperatures (above +10 °C) during this period reaches 2600–2700 °C, exceeding the physiological requirements of medium-fiber cotton varieties.

The average annual precipitation in the Bukhara and Karakul oases ranges between 114–125 mm, with about 80–85% occurring during the autumn–winter–spring period. Spring precipitation is insufficient to ensure normal germination of cotton and other crops; therefore, pre-sowing or supplementary irrigation is required annually.

The main amount of moisture evaporates during the vegetation period (1630–1708 mm). The average monthly relative air humidity during this time is



51–53%, dropping to 17–25% in July–August.

During summer, winds dominate over the region, with only 16–17 calm days per year. Dust storms occur about 15 times during the vegetation period. Hot dry winds (sukhovei) mainly invade from May to September, strongly desiccating the soil and adversely affecting the growth and development of agricultural crops.

High air temperatures, low relative humidity, and frequent winds contribute to intense soil moisture evaporation, increasing salinization processes and creating the need for frequent irrigation during the growing season.

The irrigated zone of the Bukhara region belongs to the Subtropical Desert Zone, the Central Asian Desert Province, and the Zarafshan district. Within the region, hydromorphic, automorphic, and transitional desert soils are distinguished, formed on deposits of various genesis and age.

Irrigated meadow soils (long-irrigated, newly irrigated, and newly reclaimed) are the most widespread in the region. They occur across almost all geomorphological units and develop under groundwater depths of 1–2.5 m, i.e., under conditions of intensive groundwater–capillary moistening.

The highest groundwater levels are observed during periods when water is present in the irrigation network and during leaching and vegetation irrigations. Forming under conditions of

constant or periodic groundwater moistening, where upward capillary flows prevail over downward ones, meadow soils are prone to salinization. Therefore, the reclamation and utilization of meadow soils, as well as automorphic desert soils tending toward evolutionary transformation into hydromorphic (meadow) soils, should be carried out under the conditions of a well-functioning collector–drainage network. This requirement must be ensured across all geomorphological units.

According to the degree of salinity, irrigated meadow soils vary widely—from slightly saline and leached to strongly saline. This variability is primarily determined by specific meliorative conditions, including local groundwater outflow, the presence of permeable and impermeable layers and their depth, as well as the availability of a collector–drainage system. For example, the upper part of the Bukhara delta of the Zarafshan River has more favorable meliorative conditions than its middle and especially lower parts. With certain reservations, a similar pattern can also be observed in the Karakul delta.

Meadow soils, particularly alluvial ones, are highly diverse in their mechanical composition both spatially and along the vertical soil profile. Soils located closer to irrigation sources tend to have a lighter mechanical composition than those situated farther away. Long-irrigated soils are covered at the surface by agro-irrigational deposits, which make



their composition more uniform. The thickness of these agro-irrigational sediments reaches 1.2–2.0 m, and in terms of texture they are typically medium- to heavy-loamy.

Long-irrigated and newly irrigated meadow soils, compared with other soils of the desert zone, are relatively well enriched with humus (1.1–1.4%) and nitrogen (0.08–0.12%). The gradual and deep penetration of humus in soils with agro-irrigational deposits creates significant reserves within the profile, which is largely the result of centuries-long agricultural cultivation. In less cultivated soils and in soils with a lighter mechanical composition, the content of organic matter is lower. It is especially low in irrigated meadow soils formed on ancient alluvial and deluvial–proluvial surfaces. In such areas, meadow soils developed through the evolutionary transformation of irrigated desert sandy, grey-brown, or takyrs soils, which are known for their very low natural fertility.

Irrigated meadow soils contain low amounts of available phosphates (3–90 mg/kg of soil) and low to medium levels of potassium. The gypsum content is very low (0.12–0.25%), which cannot effectively counteract the development of solonetzic processes. As a result, slight solonetzicity sometimes appears in the lower part of the root zone, caused by the entry of sodium and magnesium ions into the soil adsorption complex. Solonetzicity reduces water permeability, leads to soil compaction after irrigation, and causes

other negative properties. Soil carbonates are distributed relatively evenly throughout the profile (8.8–9.3%). Overall, irrigated meadow soils possess fairly high productive potential and constitute one of the most valuable components of the land resources of the Bukhara region.

Among meadow soils within the modern and ancient deltas of the Zarafshan River, as well as in its floodplain and the first above-floodplain terrace, marsh-meadow soils occur in small patches, many of which are irrigated. These soils form in local depressions at groundwater depths of 0.5–1.0 m under conditions of intense salinization processes; therefore, they are prone not only to waterlogging but also to salinity. Long-irrigated marsh-meadow soils found on the first terrace above the floodplain are mainly slightly saline, whereas the remaining irrigated marsh-meadow soils are moderately to strongly saline. In terms of mechanical composition, these soils are predominantly medium- and heavy-loamy, although light-loamy to sandy-loamy varieties also occur within the ancient Zarafshan delta. The humus content in the upper horizons is about 1%, while the reserves of total phosphorus and potassium are generally low.

Similar to marsh-meadow soils, fallow and virgin meadow and marsh-meadow soils occur in localized patches among irrigated meadow soils and along the periphery of oases. These soils are



very strongly saline and in some places have transformed into solonchaks. They occupy depressed relief elements and therefore exist under difficult meliorative conditions. During fallow periods they may become partially desalinized, but when reintroduced into irrigation they again undergo intensive salinization, with salts accumulating mainly in the upper horizons of the profile. These soils are poor in humus (0.5–0.7%) and vary widely in mechanical composition, ranging from heavy loamy to sandy-loamy.

Meadow-takyr soils are distributed only in the upper part of the Bukhara delta of the Zarafshan River. They form among meadow soils on relatively elevated relief elements under comparatively weak groundwater moistening, with groundwater depths of 3–4 m. During periods of maximum irrigation and water consumption, groundwater may temporarily rise to 1–2 m. All meadow-takyr soils of the Bukhara oasis are long-irrigated. The upper part of their profile, to a depth of 1–2 m, consists of agro-irrigational deposits, mainly represented by medium and heavy loams.

Located on elevated areas with relatively good local groundwater drainage, meadow-takyr soils are less affected by salinization processes than meadow soils. Therefore, they are predominantly slightly saline and well leached, while moderately and strongly saline soils occupy only small areas. The dominant type of salinity is sulfate, and

less frequently chloride–sulfate. In the plough horizon of long-irrigated meadow-takyr soils, humus content ranges from 0.5 to 1.1% and nitrogen from 0.04 to 0.12%, decreasing with depth along the soil profile. The soils are poorly to moderately supplied with available phosphorus and potassium.

Other soil types, such as irrigated takyr, desert sandy, and grey-brown soils, also occur but occupy relatively small areas. Grey-brown soils are mainly distributed along the periphery of the irrigated zone. One of their distinguishing characteristics is the presence of gypsum accumulation in the lower horizons of the soil profile.

Grey-brown meadow soils, like grey-brown and desert sandy soils, are characterized by low productivity. They require agrotechnical and meliorative measures—primarily drainage and leaching—which can significantly improve their fertility and level of cultivation.

4. Conclusion

Thus, the soils of the Bukhara region are formed under complex agroclimatic conditions of the desert zone, characterized by high temperatures, a deficit of atmospheric precipitation, and intensive wind processes. The soil cover is primarily composed of irrigated meadow soils, which possess a relatively high fertility potential but are susceptible to salinization and degradation processes. Marsh-meadow and meadow-takyr soils have more complicated meliorative



conditions and require rational water management and regular drainage.

Effective use of the region's land resources is possible through the improvement of collector–drainage systems, the introduction of water-saving technologies, and the implementation of agrotechnical measures aimed at

preventing secondary salinization and increasing the productivity of agricultural lands. Comprehensive study of soil and agroclimatic conditions represents an important scientific basis for the sustainable development of agriculture in the Bukhara region.

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