THE IMPACT OF CLIMATE CHANGE AND DESERTIFICATION PROCESSES ON GROUNDWATER IN THE NORTHERN AND SOUTHERN DISTRICTS OF THE REPUBLIC OF KARAKALPAKSTAN

Mambetullaeva S.M.
Professor, Doctor of Biological Sciences
Madraimova Svetlana Matkarimovna
2nd year doctoral student of ecology specialty
madraimovasvetlana@gmail.com
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ABSTRACT

The article examines the impact of climate change and desertification on groundwater in the northern and southern districts of the Republic of Karakalpakstan. It analyzes how rising temperatures, reduced precipitation, increased evaporation, soil salinization, dust storms, and vegetation loss affect aquifer levels and water quality. The study also highlights the role of unsustainable irrigation, agricultural runoff, and declining river inflows in worsening groundwater scarcity. The findings emphasize the need for integrated adaptation strategies, including modern irrigation, land restoration, and continuous hydrological monitoring, to ensure sustainable water management and socio-economic resilience..

Introduction. Climate change and desertification are exerting an increasingly profound influence on the groundwater systems of the northern and southern districts of the Republic of Karakalpakstan, and moreover, their combined effects continue to intensify due to the region's heightened ecological vulnerability following the Aral Sea catastrophe. Over the last several decades, average annual temperatures have risen, precipitation has steadily decreased, and evaporation rates have sharply increased; consequently, natural groundwater recharge has become substantially limited. Additionally, the shrinking of the Aral Sea has dramatically modified local climatic conditions, since the loss of a massive water surface has amplified dust storms, altered wind patterns, and accelerated soil degradation. As a result, both surface and subsurface water resources undergo constant stress, while aquifers struggle to maintain stability under new climatic pressures.

Furthermore, the northern districts such as Muynak, Kungrad, and Kegeyli are directly exposed to the newly formed Aralkum desert, and therefore they experience intense salt and dust transportation by strong winds, which infiltrates the soil and ultimately affects groundwater quality. At the same time, the southern districts including Beruniy, Turtkul, and Ellikqala face the cumulative impact of reduced river inflow from the Amu Darya, expanded irrigated agriculture, and increasing soil salinity, all of which weaken the hydrological balance. Consequently, groundwater levels decline in many areas, not solely because of climate-driven recharge reductions but also due to direct anthropogenic extraction for irrigation, domestic consumption, and industrial use. Although certain southern zones occasionally show rising

groundwater tables as a result of inefficient irrigation practices, this rise usually indicates increased salinization rather than improved water availability, and therefore such water becomes unsuitable for sustainable agricultural production.

Moreover, the progressive degradation of soils intensifies the downward movement of salts, agrochemicals, and mineralized particles, and thus groundwater quality deteriorates rapidly. As the land loses its natural vegetation cover, the soil structure becomes loose, and the infiltration of polluted sediment becomes easier, allowing contaminants to reach shallow aquifers more quickly. Consequently, groundwater in the northern districts often displays high levels of mineralization, while southern areas commonly reveal nitrate, phosphate, and pesticide residues due to agricultural runoff. These patterns collectively demonstrate that climate change, land degradation, and unsustainable water management interact to create a complex hydrological crisis.

In addition to environmental consequences, the decline in groundwater availability brings serious socio-economic challenges. Since many rural communities rely primarily on groundwater for drinking water, livestock maintenance, and irrigation, reductions in both water quantity and quality directly affect food security, public health, and household incomes. As water becomes increasingly scarce, farmers struggle to maintain crop yields, and livestock herds face limited access to reliable watering points. Consequently, local populations may be compelled to migrate in search of better living conditions, which gradually contributes to demographic shifts in ecologically stressed regions. Thus, groundwater degradation does not occur in isolation; instead, it triggers broader economic instability, social vulnerability, and long-term developmental constraints.

Conclusion. In conclusion, the combined effects of climate change and desertification have created a complex and increasingly severe impact on groundwater resources in the northern and southern districts of the Republic of Karakalpakstan. Because temperatures continue to rise while precipitation declines, aquifers receive insufficient natural recharge, and consequently groundwater levels steadily fall. Moreover, dust storms, soil salinization, and vegetation loss accelerate land degradation, and therefore groundwater quality deteriorates as salts, agrochemicals, and wind-transported particles infiltrate shallow aquifers. At the same time, unsustainable irrigation practices further intensify mineralization and water loss, which in turn threaten agricultural productivity, livestock stability, and the overall well-being of rural communities. Although the hydrological challenges differ between northern and southern districts, both share the underlying vulnerability created by the long-term ecological transformation of the Aral Sea region. Therefore, protecting groundwater requires a coordinated and science-based adaptation strategy that includes modern water-saving technologies, soil-restoration efforts, afforestation of degraded areas, and continuous monitoring of climate and hydrological indicators. Ultimately, only integrated regional cooperation and sustainable management approaches can safeguard groundwater resources and ensure environmental and socio-economic resilience for future generations.

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