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WATER AND ENERGY SECURITY IN UZBEKISTAN: CURRENT CHALLENGES AND STRATEGIC DIRECTIONS FOR SUSTAINABLE DEVELOPMENT

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ВОДНАЯ И ЭНЕРГЕТИЧЕСКАЯ БЕЗОПАСНОСТЬ В УЗБЕКИСТАНЕ: СОВРЕМЕННЫЕ ВЫЗОВЫ И СТРАТЕГИЧЕСКИЕ НАПРАВЛЕНИЯ УСТОЙЧИВОГО РАЗВИТИЯ

Abstract: The article examines Uzbekistan's water and energy challenges amid growing demand and climate constraints. It highlights the country’s heavy reliance on transboundary water, issues of soil degradation due to inefficient irrigation, and emphasizes the importance of policy reforms under the 2020–2030 agricultural strategy to improve water use efficiency and environmental sustainability.

Key words: water resources, energy security, agriculture, irrigation, transboundary water dependency, groundwater, Aral Sea basin, soil degradation, sustainable development, hydropower, environmental policy, climate adaptation

Аннотация: В статье рассматриваются проблемы, с которыми сталкивается Узбекистан в сфере водных и энергетических ресурсов в условиях растущего спроса и климатических ограничений. Особое внимание уделено высокой зависимости страны от трансграничных водных ресурсов, деградации почв вследствие неэффективного орошения, а также подчеркивается значимость реформ политики в рамках аграрной стратегии 2020–2030 годов для повышения эффективности использования воды и обеспечения экологической устойчивости.

Ключевые слова: водные ресурсы, энергетическая безопасность, сельское хозяйство, ирригация, трансграничная водная зависимость, подземные воды, бассейн Аральского моря, деградация почв, устойчивое

развитие, гидроэнергетика, экологическая политика, адаптация к изменению климата.

For many millennia, the energy contained in flowing water has served humanity reliably. Its reserves on Earth are enormous — about three-quarters of the planet's surface is covered by water. The World Ocean acts as a vast energy accumulator, absorbing most of the energy coming from the Sun. Freshwater resources consist of continuously renewable river runoff, water reserves in lakes, glaciers, reservoirs, and groundwater. The foundation of water management is represented by the surface runoff of rivers. The choice of optimal water resource use (for the national economy as a whole, not for individual sectors) must necessarily take into account the prospects for the development of the national economy, and, where applicable, international cooperation in the energy sector and the joint use of water resources [2].

It is planned to achieve an average grain yield of up to 7.5 tons per hectare by 2030, with grains occupying up to 15% of the total cultivated area (Appendix No. 2, [1]). Due to its hot and arid climate, water plays a significant role in Uzbekistan not only in agriculture (which accounted for 28.1% of GDP in 2019) and industry (30.0% of GDP in 2019), but also in ensuring basic human needs [6].

The Republic of Uzbekistan is the most densely populated country in Central Asia. As of July 2020, its permanent population reached 33,905.2 thousand people [7]. About 49% of the population resides in rural areas, and their livelihoods are entirely dependent on agriculture and related sectors. The country's geographical features significantly influence its water and energy availability, placing Uzbekistan in a unique position in the region's water balance, hydropower potential, and overall economy.

Several key points define this situation:

First, only 9.6% of the total runoff of the Aral Sea basin is formed within Uzbekistan, which is less than in Kazakhstan (2.1%) and Turkmenistan (1.2%). The majority of river runoff in the region originates in the mountains of

Kyrgyzstan (25.1%) and Tajikistan (43.4%), but these resources are used by all countries in the region. Uzbekistan, however, has the highest water consumption — 39.3% of the total water intake from the region's main rivers, the Syr Darya and Amu Darya. For comparison, Turkmenistan uses 22.87%, Tajikistan 13.05%, Kazakhstan 11.07%, and Kyrgyzstan no more than 0.8%. Another important indicator is the transboundary water dependency ratio, which reflects the share of river runoff entering the country from abroad. For Uzbekistan, this figure is very high — 77%, surpassed only by Turkmenistan at 94%, while in Kazakhstan, it stands at 42%.

Second, Uzbekistan receives 95.642 billion cubic meters of river water annually. Of this, 52.291 billion cubic meters come from the Amu Darya basin and 43.351 billion cubic meters from the Syr Darya basin. Since Uzbekistan borders all neighboring countries and is located in the center of the region, some rivers continue to flow into adjacent countries. Outflows from Uzbekistan amount to 47.562 billion cubic meters, with 36.852 billion cubic meters from the Amu Darya basin and 11.228 billion cubic meters from the Syr Darya basin. Uzbekistan itself generates about 9.701 billion cubic meters of river water. Overall, Uzbekistan utilizes approximately 57.781 billion cubic meters of water (41.472 from the Amu Darya basin and 16.309 from the Syr Darya basin) [7].

Third, internal water resources include 525 lakes and 53 reservoirs. In the upper basins of the Surkhandarya, Kashkadarya, and Chirchik rivers, there are 525 glaciers covering a total area of 154.2 square kilometers. However, rivers — about 18,000 in total — are the most important water resources in Uzbekistan. They are unevenly distributed: in the plains, only 20 meters of river per square kilometer, whereas in mountainous regions, the density of the river network is much higher. These mountain rivers are not navigable but are rich in hydropower potential.

Fourth, as rivers reach the plains, much of their flow is diverted for irrigation through canals, while another part evaporates or is absorbed into the soil. As a result, many rivers dry up and disappear in the sands. Only the Amu Darya and Syr Darya reach the Aral Sea within Uzbekistan. However, in recent years, due to high

irrigation demands, only a small fraction of these rivers' waters now reach the Aral Sea.

Fifth, an essential component of Uzbekistan's water resources is its groundwater, which supports the region's ecological systems. In arid, irrigated regions, groundwater is often the only source of freshwater. Uzbekistan has about 100 known groundwater deposits, of which 77 are freshwater reserves [6,7]. These supply water to 69 cities, 335 towns, and nearly 3,000 rural settlements.

Over the last 50 years, rapid industrial and agricultural development has negatively impacted Uzbekistan's freshwater reserves. Groundwater reserves have decreased by 35%, and some aquifers have been depleted due to unauthorized construction of water intake structures and uncontrolled water extraction [7].

It should be noted that rapid agricultural development and the expansion of land use have led to groundwater degradation and soil deterioration. A clear example is the development of the Golodnaya Steppe, where river runoff picks up soluble salts as it flows through agricultural landscapes. Existing drainage systems for surface aquifers are insufficiently effective, causing groundwater levels to rise and approach the surface, leading to soil degradation and salinization.

Such issues are particularly evident in the Syrdarya and Jizzakh regions of Uzbekistan and neighboring areas in Kazakhstan. The condition of the soil layer is directly linked to water availability and groundwater depth, which negatively affects agricultural crop yields.

Global food security data reveals the following conclusions:

1.7 billion people worldwide are at risk of falling into poverty;

Turkey is one of the most dependent countries on wheat imports from Russia and Ukraine;

In 2019, Egypt received 70% of its total grain imports from Russia, and by 2021, 41% of Egyptians at times could not afford to buy food;

The situation is even more dire in Kenya, another country dependent on Russian supplies: in 2021, 69% of the population at times could not afford food.

This is largely due to the significant share of Russia in global food production: 30% of wheat and barley, 20% of corn, and more than 50% of sunflower oil. The agricultural output of these two countries is a critical food source for the poorest populations.

In this context, the study of irrigation regimes in the cultivation of winter wheat is of great importance, as the efficiency of mineral fertilizers directly depends on maintaining optimal soil moisture. According to scientific literature, the water demand and development of winter wheat vary based on biological characteristics, soil conditions, and growth phases.

For agricultural crops—especially winter wheat under irrigated farming—soil moisture is the primary factor influencing yield. Under normal (optimal) moisture conditions, wheat can withstand heat up to 45°C, which is a common temperature during the growing season in Uzbekistan [5–7].

In conclusion, yield is directly influenced by the irrigation regime, while maintaining proper fertilizer application. It is also essential to account for soil characteristics, climatic conditions, and the integration of new technologies in agriculture.

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