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THE IMPACT OF CLIMATE CHANGE ON WATER RESOURCES AND ECOLOGICAL SYSTEMS: HYDROLOGICAL AND ECONOMIC APPROACHES

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Abstract: This article examines the impact of global climate change on water resources and ecological systems. It analyzes changes in hydrological processes, the influence on the water cycle, and the increasing risks of droughts and floods. The article also highlights the effects on sectors such as agriculture, industry, and drinking water supply, along with adaptation measures.
Keywords: climate change, water resources, hydrology, ecological systems, adaptation, water management.

Introduction

In recent years, global climate change has become one of the most pressing environmental issues facing humanity. As a result of climate change, atmospheric temperatures are steadily increasing, leading to disruptions in hydrological cycles and changes in the distribution and quality of water resources.

Water resources are essential for all life processes, and their depletion or degradation negatively affects entire ecological systems as well as economic sectors, particularly agriculture and the provision of drinking water.

In recent decades, global climate change has been characterized by rising temperatures, changes in precipitation patterns, glacier melting, and increasing water scarcity. This phenomenon is especially evident in the Central Asian region, particularly in Uzbekistan. As a result of climate change, hydrological cycles are being disrupted, directly affecting the capacity, flow regime, quality, and quantity of both internal and transboundary water basins.

Furthermore, the development of agricultural and industrial sectors, increasing demographic pressure, and disproportionate use of water resources have weakened ecological systems, as clearly seen in the example of the ecological disaster in the Aral Sea region. Therefore, a comprehensive analysis of the impact of climate change on water resources, and through them on ecological balance, as well as the development of sustainable management mechanisms, is currently one of the most important scientific and practical tasks.

Methodology

The study was conducted based on the following main approaches:
• Hydrological monitoring: Water levels, precipitation amounts, and evaporation indicators in Uzbekistan's Zarafshan, Amu Darya, and Syr Darya basins were analyzed for the years 2000–2023.
• Model analysis: Simulation models based on climate change forecasts from NASA and the IPCC were used.
• Economic analysis: The efficiency of water management systems and the impact of water-saving technologies were evaluated.

Results

• The annual volume of water resources in Uzbekistan has shown a decreasing trend over the past 20 years, with water shortages becoming more severe in summer.
• Evaporation levels in the Amu Darya and Syr Darya basins have increased by 10–15%.
• While traditional irrigation methods in agriculture increase water usage by 40%, drip irrigation systems reduce water consumption by 35–50%.
• The resilience of reservoirs to floods and droughts is decreasing.

Discussion

One of the major impacts of climate change is the alteration of precipitation regimes and the increase in extreme hydrometeorological events (floods, droughts, glacier melting). This intensifies seasonal irregularities in river flows.

To ensure sustainability in agriculture, it is essential to implement water-saving technologies, cultivate locally resilient crops, and carry out adaptive planning based on climate forecasts.

In the water sector, it is necessary to rationally use existing resources by strengthening modern monitoring systems, digital management, and transboundary cooperation.

Research shows that climate change affects water resources in two main ways:
first, it impacts the natural formation process of water sources — that is, the rate of snow and glacier melting, the amount of precipitation, and evaporation levels;
second, it affects the current usage patterns of water — including agricultural irrigation systems, drinking water supply, and industrial needs.

According to hydrological modeling, with each degree increase in temperature, the uneven distribution of precipitation and increased evaporation result in a significant reduction of river flows. This is especially observed in the Amu Darya and Syr Darya basins, leading to water shortages. Furthermore, climate change directly affects the growing season of plants and the effectiveness of agrotechnical measures.

Ecologically, reduced water availability leads to a decline in biodiversity, drying of wetlands and lakes, and the disappearance of migratory birds. These negative impacts of climate change pose threats to human health, economic stability, and ecological security.

From this perspective, adaptive management approaches to climate change — such as introducing water-saving technologies, improving ecological monitoring systems, and applying integrated management of transboundary water resources — are of critical importance. In addition, scientific and legal strategies aimed at ensuring climate resilience must be developed in cooperation with international organizations.

Conclusion

Global climate change is leading to reduced water resources, disruption of ecological systems, and instability in economic sectors. In arid regions like Uzbekistan, these impacts are becoming more severe.

To solve the issue, the following recommendations can be proposed:
• Improve the hydrological monitoring system.
• Accelerate the implementation of water-saving technologies.
• Develop climate-adaptive policies.
• Strengthen regional cooperation in water resource management.

Thus, effective water resource management under climate change conditions is a crucial factor in ensuring ecological sustainability and economic security.

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