THE EMERGENCE OF WATER RESOURCE SCARCITY AND ITS ECOLOGICAL IMPACTS

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Abstract: This article deeply analyzes the causes of water resource scarcity on a global scale and in the case of the Republic of Uzbekistan, linking it to climate change, population growth, urbanization, and anthropogenic factors. During the research process, modern scientific approaches such as systematic analysis, statistical generalization, and ecological monitoring were utilized. Based on digital data, the dynamics of household provision with basic drinking water services between 2010 and 2025 are highlighted (the general indicator increased from 73.4% to 99%, in urban areas from 91.4% to 99.8%, and in rural areas from 60.5% to 98%). Furthermore, the article thoroughly examines negative ecological consequences such as the disruption of natural ecosystems due to water scarcity and the reduction of natural water body surfaces, acceleration of secondary soil salinization and desertification processes, decline in agricultural productivity, narrowing of habitats for flora and fauna leading to a decrease in biodiversity, as well as the loss of the self-purification capacity of water bodies resulting in worsened water quality and ecological environment. The results of the scientific research indicate that to mitigate emerging ecological threats, it is necessary to introduce water-saving technologies in agriculture, improve water resource management systems, and strengthen transboundary cooperation.

Keywords: water scarcity, climate change, drinking water supply, ecological balance, soil salinization, desertification, biodiversity.

Introduction. Against the background of ecological crises and climate changes occurring on a global scale today, water resource scarcity has already become one of the most acute and threatening problems facing humanity [1, 3]. The rapid development of industry, the increase in water consumption volumes in agriculture, and urbanization processes have sharply intensified the pressure on natural water reserves [2]. Scientific studies have confirmed that the limitation of water resources and their mismanagement cause serious damage not only to agricultural crop production volumes but also to the overall ecological balance [4, 5]. This problem manifests its devastating impact not only on industrially developed regions but also on arid and semi-arid regions, leading to the disruption of ecosystems, soil degradation, and deterioration of human health [6]. Therefore, deeply studying the causes of water scarcity and analyzing its impact on the environment is one of the most important tasks facing the scientific community today.

This global ecological problem is manifested even more prominently at the regional scale, particularly in regions dependent on transboundary water basins such as Central Asia and Uzbekistan [7, 10]. The arid climate of the region, the rapid melting of glaciers, and outdated water resource management systems further exacerbate water shortages [18, 19]. The disruption of the water balance in the lower reaches of the Amudarya and Syrdarya rivers, as well as changes in groundwater levels and mineralization degrees, pose a serious threat to the socio-economic stability of the region [8, 12].

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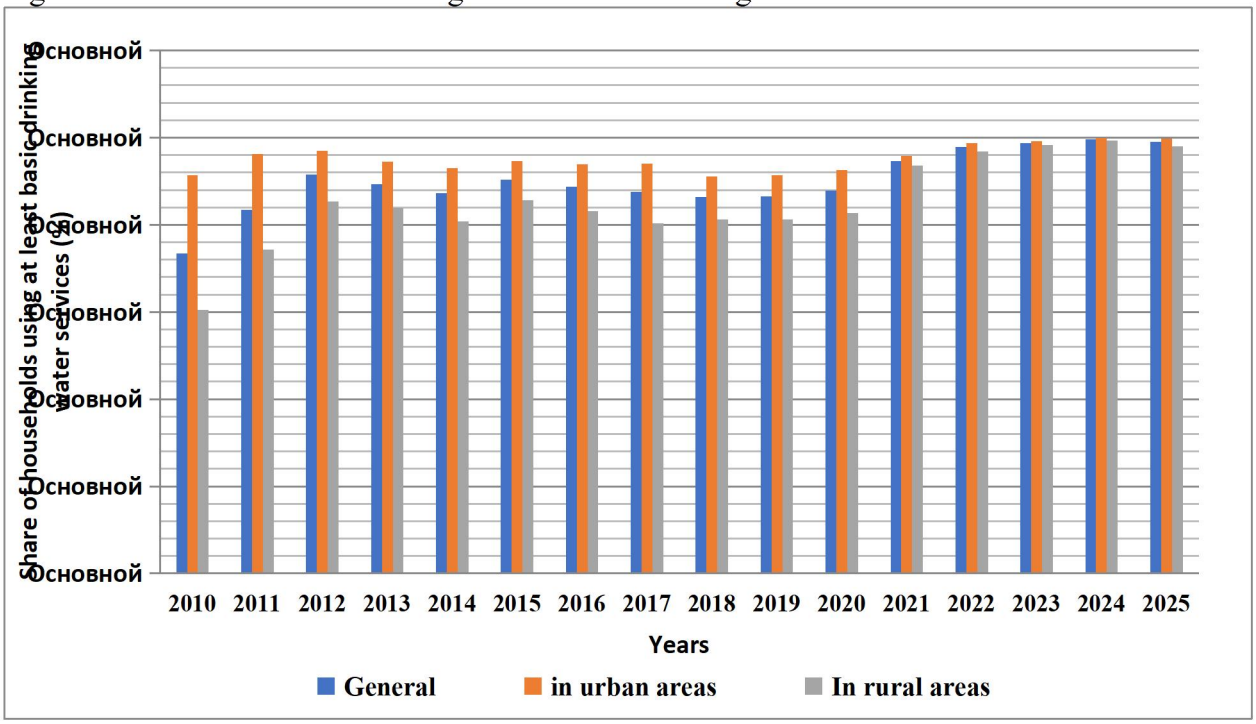
Furthermore, issues of water resource distribution and efficient utilization are acquiring urgent importance in internal irrigation regions such as Kashkadarya, requiring the use of modern software tools and modeling methods for irrigating agricultural crops [13, 15, 16]. Ensuring regional water security and improving management mechanisms demonstrate the necessity of transitioning to transboundary cooperation and water-saving technologies [17].

In order to mitigate the negative consequences of water resource scarcity and ensure sustainable development, innovative approaches and mechanisms for utilizing alternative water sources are being intensively studied. Under the conditions of Uzbekistan, scientific research is being conducted on wastewater treatment, their secondary application in agriculture, and the reduction of losses in irrigation networks [9, 11]. At the same time, efforts aimed at monitoring soil salinization and optimizing the water balance serve to preserve ecological stability [14].

Methodology. During the research process, systematic analysis was used to study the socio-economic and ecological factors of water resource scarcity, statistical generalization was applied for the comparative evaluation of recent hydrological changes and drinking water indicators, and ecological monitoring methods were utilized to observe the state of water bodies.

Results and Discussion. The rapid growth of the population and urbanization processes are daily increasing the demand for natural water resources. The expansion of agricultural and industrial sectors places additional pressure on water reserves, leading to a sharp reduction in available resources and an increased risk of scarcity. To ensure the uninterrupted supply of clean drinking water to the population and prevent water waste, it is necessary to introduce modern water-saving technologies and fundamentally improve the culture of water use.

Figure 1. Share of households using at least basic drinking water services



Between 2010 and 2025, the level of provision of households with at least basic drinking water services in our country demonstrated a sharp growth and a dynamic of positive changes. According to the presented statistical data and graphical analyses, while in 2010 only 73.4 percent of the total population nationwide had access to basic drinking water services, this indicator consistently

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increased in subsequent years. Specifically, this indicator reached 83.4 percent in 2011 and 91.5 percent in 2012. Although the overall supply level fluctuated within a stable range of 86.4 percent to 90.4 percent between 2013 and 2020, a fundamental turning point occurred in the sector starting from 2021, and the indicator rose to 94.7 percent. This positive dynamic continued consecutively, amounting to 97.8 percent in 2022, 98.7 percent in 2023, 99.6 percent in 2024, and 99.0 percent according to forecasts for 2025. This situation indicates that the coverage of the population with drinking water supply nationwide has been brought to a nearly complete level and demonstrates the high efficiency of state programs and investment projects implemented to modernize water infrastructure.

One of the most important and notable aspects of the analyzed period is the gradual elimination of the disproportion and regional gap in drinking water supply between urban and rural areas. Initially, while in 2010 the indicator of household access to drinking water services in urban areas stood at 91.4 percent, in rural areas this indicator was markedly lower, accounting for only 60.5 percent, which showed a massive gap of 30.9 percentage points between urban and rural areas. However, in subsequent years, as a result of priority measures regarding the laying of water pipelines, the construction of new water facilities, and the repair of existing ones in rural regions, this gap sharply narrowed. The supply level in rural areas rose to 85.4 percent in 2012, 93.6 percent in 2021, and 99.3 percent by 2024. In urban areas, the indicators grew stably, reaching from 91.4 percent in 2010 to 99.9 percent in 2024 and 99.8 percent in 2025. Consequently, by 2025, the gap between urban and rural areas amounted to only 1.8 percent (99.8% for urban and 98.0% for rural), aligning the living standards of the rural population with the urban level.

Such large-scale development of infrastructure and bringing the coverage of drinking water supply to 99 percent has not only socio-economic, but also critically important ecological and hygienic significance. Providing the population with safe and high-quality drinking water serves, on the one hand, to prevent various infectious diseases and waterborne illnesses and strengthen the health of human capital, and on the other hand, prevents irregular and illegal use of surface and groundwater resources. The establishment of modern and centralized water supply systems in rural regions significantly reduces ecological risks such as excessive and uncontrolled extraction of groundwater reserves, soil salinization, and the environmental degradation of water bodies. In conclusion, the dynamics from 2010 to 2025 clearly demonstrates that tremendous results have been achieved in attaining sustainable development goals in the country, mitigating the consequences of drinking water scarcity, and creating equal and high-quality living conditions for all strata of the population.

A comprehensive and deep study of the emergence of water resource scarcity and its ecological and socio-economic impacts on nature and society requires multifaceted and complex scientific approaches. In order to prepare this article and scientifically substantiate the research process, modern scientific methods such as systematic analysis, statistical generalization, and ecological monitoring were utilized. These methodological approaches provided the opportunity to objectively assess the transboundary characteristics of the water scarcity problem, the impact of climate change on hydrological processes, and trends of ecological changes in the regions. The scientific and practical significance of these approaches lies in the fact that they ensure viewing existing problems not as isolated factors, but as an integral part of a single biospheric and socio-economic system.

First of all, the systematic analysis approach served to deeply study the problem of water scarcity within a complex of socio-economic and ecological factors. The shortage of water resources is not merely a problem within the scope of natural sciences or hydrology; it is closely linked to socio-economic processes such as population growth, the level of urbanization, rapid industrial

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development, and the increase in water consumption volumes in agriculture. Through the systematic analysis method, the mechanisms of mutual influence of these factors—specifically, the cause-and-effect relationships between soil degradation, secondary salinization, and ecosystem disruption caused by inefficient water management in agriculture—were clearly revealed. This showed that addressing the problem requires not only engineering and technical solutions, but also the combined application of social governance and economic incentive mechanisms.

Secondly, using the statistical generalization method, recent hydrological changes, water consumption, and indicators of household provision with basic drinking water services were comparatively evaluated. Specifically, analyzing official statistical data between 2010 and 2025, it was generalized with precise figures that the overall drinking water supply coverage of the population nationwide increased from 73.4% to 99%, including 99.8% in urban areas and 98% in rural areas. This statistical analysis demonstrated that initial disparities between urban and rural areas (for instance, coverage in rural areas was only 60.5% in 2010) have been almost entirely eliminated as a result of reforms implemented over the years, enabling the expression of the positive change dynamics in figures. At the same time, statistical generalization helped evaluate volume reductions in river basins and water bodies in numerical form.

Thirdly, the ecological monitoring method served as an important tool in analyzing the actual state of water bodies and their change trends by regional breakdown. The reduction of water surfaces, soil mineralization, and biodiversity narrowing processes in the lower reaches of the Amudarya and Syrdarya rivers, the Aral Sea region, and internal irrigation networks were observed based on ecological monitoring data. Monitoring results confirmed that the self-purification capacity of natural water bodies has declined, and the deterioration of water quality is causing serious damage to the habitats of flora and fauna species.

Conclusion. In this scientific research process, the causes of water resource scarcity on a global scale and in the case of the Republic of Uzbekistan, as well as its negative impacts on the environment, economy, and the lifestyle of the population, were comprehensively and deeply analyzed. The research results demonstrated that climate change, the rapid melting of glaciers, population growth, urbanization processes, and the increase in water consumption volumes in agriculture are sharply intensifying the pressure on natural water reserves. Especially in the lower reaches of the Amudarya and Syrdarya rivers and the Aral Sea region, the disruption of the water balance is leading to the destabilization of local ecosystems, soil degradation, secondary salinization, and the acceleration of desertification processes. The reduction of natural water body surfaces, in turn, narrows the habitats of flora and fauna, causing a decrease in biodiversity and the loss of the self-purification capacity of water bodies. At the same time, the study proved on the basis of statistical data that tremendous positive results have been achieved in our country in recent years regarding the management of water resources and the improvement of drinking water supply. Specifically, between 2010 and 2025, the level of household provision with basic drinking water services nationwide increased from 73.4 percent to 99 percent, almost completely eliminating the longstanding gap between urban (99.8%) and rural (98%) areas. This situation demonstrates the high efficiency of state programs and investment projects, serving not only to improve socio-economic conditions but also to mitigate ecological risks and prevent the unregulated extraction of groundwater resources.

REFERENCES

1. Pimentel, D., Berger, B., Filiberto, D., Newton, M., Wolfe, B., Karabinakis, E., ... & Nandagopal, S. (2004). Water resources: agricultural and environmental issues. BioScience, 54(10), 909-918.

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2. Chowdhary, P., Bharagava, R. N., Mishra, S., & Khan, N. (2019). Role of industries in water scarcity and its adverse effects on environment and human health. In Environmental concerns and sustainable development: Volume 1: Air, water and energy resources (pp. 235-256). Singapore: Springer Singapore.
3. Postel, S. L. (2000). Entering an era of water scarcity: the challenges ahead. Ecological applications, 10(4), 941-948.
4. Tzanakakis, V. A., Paranychianakis, N. V., & Angelakis, A. N. (2020). Water supply and water scarcity. Water, 12(9), 2347.
5. Jiang, Y. (2009). China's water scarcity. Journal of environmental management, 90(11), 3185-3196.
6. Israilova, E., Voronina, A., & Shatila, K. (2023, October). Impact of water scarcity on socio-economic development. In E3S web of conferences (Vol. 458, p. 08027). EDP Sciences.
7. Rakhmatullaev, S., Huneau, F., Celle-Jeanton, H., Le Coustumer, P., Motelica-Heino, M., & Bakiev, M. (2013). Water reservoirs, irrigation and sedimentation in Central Asia: a first-cut assessment for Uzbekistan. Environmental earth sciences, 68(4), 985-998.
8. Rakhmatullaev, S., Huneau, F., Kazbekov, J., Celle-Jeanton, H., Motelica-Heino, M., Le Coustumer, P., & Jumanov, J. (2012). Groundwater resources of Uzbekistan: an environmental and operational overview. Central European Journal of Geosciences, 4(1), 67-80.
9. Karshiev, R., Eshev, S., Makhmudov, K., Makhmudov, U., Eshev, A., & Hazratov, A. (2025, June). Water balance of the Republic of Uzbekistan under conditions of water scarcity: Problems and solutions. In AIP Conference Proceedings (Vol. 3286, No. 1, p. 040038). AIP Publishing LLC.
10. Abuduwaili, J., Issanova, G., & Saparov, G. (2018). Water resources and impact of climate change on water resources in Central Asia. In Hydrology and Limnology of Central Asia (pp. 1-9). Singapore: Springer Singapore.
11. Teshayev, S., Umirqulova, F., Abduraimova, D., Hashimova, S., Nasirova, S., Sharipova, Z., ... & Zokirov, K. (2026). Investigating the necessity of water recycling and reuse of unconventional water in the context of water resources management: a case study of Uzbekistan. Brazilian Journal of Biology, 86, e300307.
12. Khamidov, M., Ishchanov, J., Khamidova, S., Isabaev, K., & Altmishev, A. (2024, June). Water scarcity under global climate change: Ways of addressing them in the lower reaches of the Amu Darya River in Uzbekistan. In BIO Web of Conferences (Vol. 103, p. 00021). EDP Sciences.
13. Abdullaev, B., Razzakov, R., Nasibov, B., Mukhamedov, G., Aytmuratov, T., & Dadajonov, B. (2025, October). Estimating the Amount of Water Required for Crop Irrigation Based on the Application of FAO's CROPWAT Program in the Case of Kashkadarya Region. In BIO Web of Conferences (Vol. 151, p. 04003). EDP Sciences.
14. Nasibov, B., Kamalova, M., Yuldasheva, C., Artikbekova, F., Sapaev, I., Nazarov, K., & Saydullaev, S. (2025, July). Monitoring the level of salinity of irrigated lands and groundwater in Andijan region. In AIP Conference Proceedings (Vol. 3256, No. 1, p. 040003). AIP Publishing LLC.
15. Abdullaev, B. D., Razzakov, R. I., Okhunov, F. A., & Nasibov, B. R. (2023, April). Modeling of hydrogeological processes in irrigation areas based on modern programs. In E3S Web of Conferences (Vol. 401, p. 02006). EDP Sciences.
16. Eshmirzayev, Z. (2025). Qashqadaryo vohasi irrigatsiya tizimi, uning o ‘lka hayotida tutgan o ‘rni va ahamiyati. The Lingua Spectrum, 1(1), 377-380.

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17. Ahn, Y. J., & Juraev, Z. (2024). Examination of regional water governance and water insecurity issues in Central Asia. Sustainable Water Resources Management, 10(3), 118.
18. Libert, B., Orolbaev, E., & Steklov, Y. (2008, August). Water and Energy Crisis in Central Asia. In China & Eurasia Forum Quarterly (Vol. 6, No. 3, p. 9).
19. Mussatayev, S., Muminov, N., & Orynbayev, Z. (2024). Water scarcity dynamics in central Asia: implications for regional stability. Journal of Central Asian Studies, 96(4), 20-31.

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