

## Approaches to the Distribution of Transboundary Water Resources in Central Asia

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### ABSTRACT

**Objective:** The sustainable management of transboundary water resources is a critical issue for the countries of Central Asia due to the region's arid climate and growing demand for water. Major rivers such as the Amu Darya and Syr Darya flow across several national boundaries, making equitable distribution among Uzbekistan, Kazakhstan, Kyrgyzstan, Tajikistan, and Turkmenistan essential for regional stability and development. This article examines different approaches to the allocation of transboundary river waters, including distribution based on geographical relevance, historical circumstances, equality between states, proportionality to the land area of the states, proportionality to irrigated agricultural land, and proportionality to population size. **Method:** Using statistical data from the Aral Sea basin, the study compares these allocation models and calculates the potential water shares for each country under different methods. **Results:** The analysis shows that each method produces significantly different outcomes in terms of national water availability. In particular, Uzbekistan's share ranges from 16.48 km<sup>3</sup> under equal distribution to 48.82 km<sup>3</sup> when allocation is based on population. The findings suggest that while each method has certain advantages, the population-based approach better reflects social needs and supports equitable access to water resources. **Novelty:** The study highlights the importance of considering demographic factors, regional cooperation mechanisms, and international legal principles when designing sustainable water distribution frameworks in Central Asia. These insights contribute to the development of balanced and cooperative water management strategies for transboundary river basins in the region.

## INTRODUCTION

The Central Asian region is arid in terms of natural and climatic conditions, and its sustainable development largely depends on water resources. The major rivers of the region, such as the Amu Darya and the Syr Darya, flow through the territory of several countries and therefore are of particular importance as transboundary water bodies. The issue of rational and equitable use of water among Uzbekistan, Kazakhstan, Kyrgyzstan, Tajikistan and Turkmenistan, which are located in the basins of these rivers, is one of the important factors of regional stability [1].

The issue of sharing transboundary river waters is relevant not only economically, but also ecologically and politically. Irrigated agriculture, hydropower, drinking water supply and industrial needs are increasingly increasing the demand for water resources. At the same time, climate change, population growth and aging water infrastructure are increasing the need for efficient use of existing resources. In particular, the Aral Sea tragedy has clearly demonstrated the need to create coherent and coordinated mechanisms for the water management system in the region [2].

This article analyzes the main methods of water allocation of transboundary rivers in Central Asia, the existing legal and regulatory framework, regional cooperation mechanisms, and ways to ensure a balance of interests in water use. It also examines the prospects for developing effective cooperation between the countries of the region based on integrated water resources management approaches and modern international experience [3].

The issues of transboundary river water allocation, sustainable water supply for agriculture, industry and the population are currently of great importance. Many scientists from Uzbekistan have conducted research in this area. In particular, the article by Erkinjon Abdumalikov, *The politics of water diplomacy in Central Asia: Uzbekistan's role in transboundary river cooperation*) is about water diplomacy and water policy in Central Asia, in which the Amu Darya and Syrdarya rivers are analyzed from the perspective of regional cooperation [4]. The author studies the development trends of water diplomacy in the context of Uzbekistan's foreign policy, as well as the impact of this trend on transboundary water allocation [5].

Ravshankulov Firdavs, *Security Issues of Transborder Rivers and Major Water Sources of Central Asia*) studies water security and water distribution strategies in the region, including water resource conservation technologies, modernization of water infrastructure, and solutions related to the Aral Sea problems [6].

Hikmatjon Avezov, *Establishing International Cooperation In The Use Of Transboundary Water Resources In Uzbekistan: Historical Approach And Contemporary Measures*) writes about the history and modern measures of international cooperation between countries using transboundary water resources. The author analyzes the transformation of water policy and regional governance mechanisms in the post-Soviet era in a legal and political context [7].

Nodirjon Sa'diev, *International Legal Regulation of the Use of Transboundary Waters*) examines the issues of regulating the use of water resources on the basis of international law, analyzes the principles of equitable distribution of water based on UN conventions and international norms [8].

Muzaffar Tangirkulov, *Transboundary Water Resources: Legal Problems and Solutions between Uzbekistan and Central Asian States*) focuses on the legal problems of using transboundary waters and their solutions, and also analyzes the issues of water distribution based on regional agreements.

Foreign authors Shokhrukh-Mirzo Jalilov, Olli Varis and Marko Keskinen (2015, *Sharing Benefits in Transboundary Rivers: An Experimental Case Study of Central Asian Water-Energy-Agriculture Nexus*) They analyze water distribution strategies in the context of water-energy-agriculture (Water-Energy-Food) in hydro-economic models. The goal is to eliminate conflicts of interest arising from water use and identify opportunities for cooperation to benefit all countries [9].

Erika Weinthal, *Water and Post-Conflict Peacebuilding*) studies transboundary water resources in the context of political relations and cooperation. She analyzes the political dynamics, cooperation, and conflict factors in water

resource management after independence. Resul Yalçın and Assylay Imagambetova, Problems of sharing transboundary water resources in Central Asia) analyze water distribution, resource competition, and political conflicts on major transboundary rivers such as the Syr Darya and the Amu Darya. The authors highlight the complexities associated with the departure from the central governance model after independence and note the need for effective water management [10].

## RESEARCH METHOD

The study used a comprehensive approach to general and special scientific research methods. In particular, the analysis and synthesis method, the comparison and grouping method, and statistical analysis methods were used.

## RESULTS and DISCUSSION

The main methods of distributing transboundary river waters in Central Asia, the existing legal and regulatory framework, regional cooperation mechanisms, and ways to ensure a balance of interests in water use are analyzed [11]. In distributing transboundary river waters, S.Sh. Mirzaev (Mirzayev S.Sh. Osnovnie institute upravleniya vodnimi resursami basseyna Aralskogo morya) indicates the following methods:

1. Based on administrative-geographical affiliation;
2. Based on socio-economic principles;
3. Based on the historically formed situation;
4. Based on equality between all states;
5. Proportionally to the land area of the state bordering a particular water basin;
6. Proportionally to the existing irrigated area of the states bordering a particular water basin [12];
7. proportionally to the number of people living within a particular water basin.

We calculate how much water will belong to Uzbekistan when distributing the waters of transboundary rivers. We use Table 1 to calculate this:

**Table 1.** Land use and population of the Aral Sea basin countries

<b>Countries</b>	<b>Area of countries (thousand hectares)</b>	<b>Crop area (thousand hectares)</b>	<b>Population (thousands of people)</b>
Kazakhstan	34440	1658.8	2647.1
Kyrgyzstan	12490	595	2481.2
Tajikistan	14310	769.9	5620
Turkmenistan	48810	1805.3	4521.1
Uzbekistan	44884	5207.8	22192
Total for the Aral Sea basin	154934	10036.8	37461.4

Table 1 contains data from 2 regions of Kazakhstan and 3 regions of Kyrgyzstan that are part of the Aral Sea basin.

Water comes to the Aral Sea basin from two rivers - the Amu Darya and the Syr Darya. We need to determine the amount of water that should be distributed between the countries. According to statistics, the average annual flow of the Amu Darya is 73.57 cubic km, and the Syr Darya is 38.84 cubic km. The total annual flow of the two rivers is 112.41 km<sup>3</sup>. An average of 112.41 cubic km of water should be distributed between the countries each year [13].

According to S.Sh. Mirzaev, 30 cubic km of water is required per year to maintain the Aral Sea in its current state (this is the amount equal to the amount of evaporation and other losses in the area of 30.0 thousand sq km of the sea). Taking this into account, the amount of water that can be distributed between the countries is 82.41 cubic km per year [14]. When this amount of water is distributed in four ways, we determine the amount of water belonging to the countries.

1. Equal distribution based on the equality of states. If the waters of the Aral Sea basin are distributed equally among the states, each state will receive an average of 82.41 cubic kilometers per year [15]. The calculation is based on the following formula:

$$\text{Appropriate amount of water} = \frac{\text{Total water content}}{\text{Number of states}} = \frac{82.41 \text{ km}^3}{5} = 16.48 \text{ km}^3 \quad (1)$$

Here:

- Appropriated water volume - the volume of water that belongs to each state on the basis of equal rights;
- Total water volume - the average annual volume of water that can be distributed in the aral sea basin;
- Number of states - the number of states receiving water from the amu darya and syr darya rivers that are part of the aral sea basin (excluding afghanistan).

Each country is allocated 16.48 km<sup>3</sup> of water per year. This method of water distribution does not take into account the real water needs of the population in the region. The needs of each person are not met in the distribution of water, and it leads to a violation of the equal rights of each person in the region [16]. In addition, in some countries, excess water leads to water waste, while in some countries, the possibilities of irrigated agriculture decrease or disappear due to water shortages.

2. Distribution of water according to the area of countries.

Based on Table 1, the distribution of water according to the area of the countries is carried out using the following formula.

$$\text{Appropriate amount of water} = \frac{\text{Total water content}}{\text{Total area}} * \text{Area belonging to each state} \quad (2)$$

Here:

- Total water volume - the share of water allocated to countries based on their area;
- Total area - the total area of the countries in the aral sea basin;
- Area of each country - the areas of the regions of each country included in the aral sea basin (the areas of the regions of kazakhstan and kyrgyzstan included in the aral sea basin were taken).

The calculations are shown in Table 2. From the table, when water is distributed in this way, Kazakhstan will have a total of 18.32 cubic km, Kyrgyzstan 6.64 cubic km,

Tajikistan 7.61 cubic km, Turkmenistan 25.96 cubic km, and Uzbekistan 23.88 cubic km of water from the Aral Sea basin water resources [17].

**Table 2.** Water distribution of the Aral Sea basin water resources based on the area of the countries

Countries	Area of countries (thousand ha)	Amount of water to be distributed, km <sup>3</sup>	Amount of water available, km <sup>3</sup>
Kazakhstan	34440	82.41	18.32
Kyrgyzstan	12490	82.41	6.64
Tajikistan	14310	82.41	7.61
Turkmenistan	48810	82.41	25.96
Uzbekistan	44884	82.41	23.88
Total for the Aral Sea basin	154934		82.41

3. Distribution of water resources according to the area of irrigated agriculture of the countries.

Based on Table 2, the distribution of water resources according to the area of irrigated agriculture of the countries is carried out based on the following formula:

$$\text{Appropriate amount of water} = \frac{\text{Total water content}}{\text{Total cultivated areas}} * \text{The cultivated area of each country} \quad (3)$$

Here:

- Total sown area – total sown area of the countries in the Aral Sea basin based on irrigated agriculture;
- Sown area of each country – sown area based on irrigated agriculture. (Data from the regions of the Republics of Kazakhstan and Kyrgyzstan included in the Aral Sea basin were taken).

The calculations were as shown in Table 3:

**Table 3.** Water distribution based on irrigated agriculture area

Countries	Irrigated area (thousand hectares)	Amount of water to be distributed, km <sup>3</sup>	Amount of water available, km <sup>3</sup>
Kazakhstan	1658.8	82.41	13.62
Kyrgyzstan	595	82.41	4.89
Tajikistan	769.9	82.41	6.32
Turkmenistan	1805.3	82.41	14.82
Uzbekistan	5207.8	82.41	42.76
Total for the Aral Sea basin	10036.8		82.41

Based on the analysis, in this method of water distribution, Kazakhstan will have 13.62 cubic km, Kyrgyzstan 4.89 cubic km, Tajikistan 6.32 cubic km, Turkmenistan 14.82 cubic km and Uzbekistan 42.76 cubic km of water[18].

#### 4. Water distribution based on population.

Based on Table 3, water distribution of countries based on population is carried out using the following formula:

$$\text{Appropriate amount of water} = \frac{\text{Total water content}}{\text{Total population}} * \text{The population of each country} \quad (7.2.4)$$

Here:

- Total population – the total population of the countries in the Aral Sea basin;
- Population of each country – the population of each country within the Aral Sea basin (data from the regions of the Republics of Kazakhstan and Kyrgyzstan within the Aral Sea basin are taken).

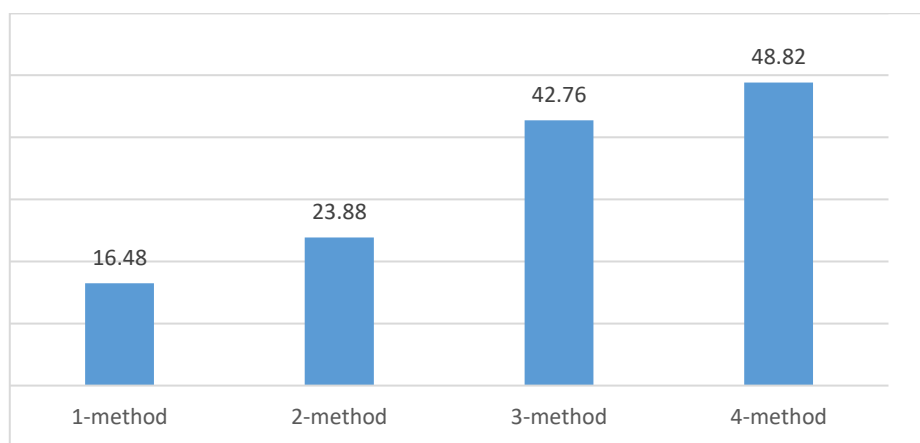
The analysis is presented in Table 4:

**Table 4.** Water distribution based on the population of the countries

Countries	Population of countries, thousand people	Amount of water to be distributed, km <sup>3</sup>	Amount of water available, cubic km
Kazakhstan	2647.1	82.41	5.82
Kyrgyzstan	2481.2	82.41	5.47
Tajikistan	5620	82.41	12.36
Turkmenistan	4521.1	82.41	9.94
Uzbekistan	22192	82.41	48.82
Total for the Aral Sea basin	37461.4		82.41

When water is distributed according to this method, Kazakhstan will have 5.82 cubic km, Kyrgyzstan 5.47 cubic km, Tajikistan 12.36 cubic km, Turkmenistan 9.94 cubic km, and Uzbekistan 48.82 cubic km.

In the four analyzed methods of water distribution, the amount of water belonging to Uzbekistan will be 16.48 cubic km in method 1, 23.88 cubic km in method 2, 42.76 cubic km in method 3, and 48.82 cubic km in method 4. The diagram of the amount of water belonging to Uzbekistan under different methods is shown in Figure 1.



**Figure 1.** Water distribution under different methods (The amount of water belonging to Uzbekistan, cubic km).

The most optimal method of water distribution for Uzbekistan is the method of distribution proportional to the population.

When distributing water in the 4th method, Uzbekistan will have the largest amount of water. This is enough to meet the needs of the state and the population. Having this amount of water is considered the most optimal for Uzbekistan. Because it expresses the right of every person to live. This is also indicated in international law. In particular, the international protocol "Water Distribution of Interstate and Transboundary Rivers", approved in Helsinki in 1962, also emphasizes that the needs of every person should be taken into account [19].

## CONCLUSION

**Fundamental Finding :** The analysis shows that, although each of the above approaches is justified to a certain extent, they do not fully cover all factors when used separately. However, the demographic factor is of great importance in Central Asia, especially in the conditions of Uzbekistan. Uzbekistan is the country with the largest population in the region, and the social and economic need for water resources is high. Therefore, the method of distributing transboundary river waters proportionally to the population of the countries can be considered the most acceptable and socially justified model for Uzbekistan. **Implication :** This approach ensures social justice in the use of water resources, strengthens drinking water security, supports food and economic stability, and establishes human interests as a priority criterion in regional cooperation. **Limitation :** The analysis shows that, although each of the above approaches is justified to a certain extent, they do not fully cover all factors when used separately. **Future Research :** Thus, an approach based on demographic indicators in the allocation of transboundary water resources in Central Asia is more in line with Uzbekistan's interests and appears to be a promising direction in forming a sustainable and equitable water management system.

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