International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-6, August, 2019

Resources of River Runoff of Kazakhstan

Sayat Alimkulov, Aisulu Tursunova, Assel Saparova, Kairat Kulebaev, Alfiya Zagidullina, Ahan Myrzahmetov

Abstract: ***The role of river runoff resources is very important for Kazakhstan – the country located deep within the continent, with an arid climate, and experiencing water shortage. With such a geographical location, the hydrological regime of rivers is characterized by the considerable spatiotemporal variability, thereby complicating the water resousrces management. The issue of evaluating water resources is particularly relevant not only from a scientific point of view. In recent years, it has gained socio-economic and political nature due to the increasing role of anthropogenic factors (including geopolitical ones), as well as increasingly more noticeable changes in the global and regional climate. Based on hydrometric information using modern methodology, the water resources of eight water-resources basins (WRBs) on the territory of Kazakhstan have been estimated in the context of water-resources regions.***

Index Terms: ***average runoff, river runoff, water flowrate, water resources, water-resources basin, water-resources region.***

I. INTRODUCTION

There is no doubt that in the 21st century the main problem of mankind will be that of water resources. "Water is a matter of life and death", "The world of depleting water supplies", "Water resources under stress", "Water of the whole world – is it enough?" – these are the recent-years headings of document sections of the World Meteorological Organization (WMO) [1]. In the Message of the President of the Republic of Kazakhstan N.A. Nazarbayev to the people of Kazakhstan "Kazakhstan 2050" an acute shortage of water is named one of the ten global challenges of the 21st century. "The water is an extremely limited resource, and the struggle for the possession of water sources is becoming a major factor in geopolitics, is one of the causes of tension and conflict on the planet. 2050 is the real term at which the world community targets today in its development" [2].

II. PROPOSED METHODOLOGY

A. Block Diagram

The WMO figured out four levels of stress associated with water shortages. As per this gradation, the areas where more than 40 % of the available water are used belong to the fourth, highest level of stress. Here, water is consumed with greater intensity than the natural replenishment [1]. In Kazakhstan, this gradation is exceeded in five of the eight water-resource basins (hereinafter referred to as WRBs), and in the Shu-Talas and Nur-Sarysu WRBs this index is 0.98 and 1.00, respectively, that is, the entire river runoff is in use. The exceptionally high spatiotemporal variability of river runoff and the significance of its transboundary component greatly complicate the problem of the water supply in the republic. Due to the unfavorable geographical position in the lower reaches of the rivers of the transboundary basins, the Republic of Kazakhstan largely depends on water management activities in neighboring China, Uzbekistan, Kyrgyzstan, and Russia (Fig. 1).

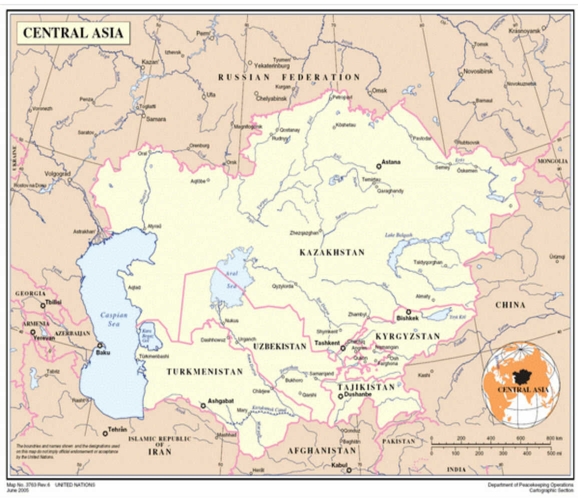

Fig. 1. Location of Kazakhstan in Central Asia

According to the Fourth Report of the Intergovernmental Panel on Climate Change, climate warming is expected to lead to changes in atmospheric circulation and a decrease in precipitation.

Revised Manuscript Received on October 30, 2019.
* Correspondence Author
Sayat Alimkulov, "Institute of Geography", Ministry of Science and Education of the Republic of Kazakhstan, Almaty, Kazakhstan.
Aisulu Tursunova, "Institute of Geography", Ministry of Science and Education of the Republic of Kazakhstan, Almaty, Kazakhstan.
Assel Saparova, "Institute of Geography", Ministry of Science and Education of the Republic of Kazakhstan, 050010, Almaty, Kazakhstan; Satbayev University, Republic of Kazakhstan, Almaty, Kazakhstan.
Kairat Kulebaev, "Institute of Geography", Ministry of Science and Education of the Republic of Kazakhstan, Almaty, Kazakhstan; Satbayev University, Almaty, Kazakhstan.
Alfiya Zagidullina, "Institute of Geography", Ministry of Science and Education of the Republic of Kazakhstan, Almaty, Kazakhstan.
Ahan Myrzahmetov, "Institute of Geography", Ministry of Science and Education of the Republic of Kazakhstan, Almaty, Kazakhstan.

Under some scenarios, by 2100 the precipitation decrease may reach almost 20 %. In addition, studies showed that an intensive melting of glaciers continues in the zone of the runoff formation of the Syr Darya and Amu Darya Rivers. According to various sources, over 50 years, the glaciers have decreased in volumes from 20 to 40 %, and in recent years, the rate of decline has been about 1 % per year. The disappearance of glaciers will lead to the disappearance of the life-carrying rivers [3].

Significant changes of the values and structure of consumption, the exacerbation of conflicts and rifts between individual water users, including the increase of water consumption for the development of industries of the Kazakhstan economy, the aggravation of interstate water relations in transboundary basins can take place in the country due to the projected reduction of the resources of river runoff. Global and regional climate change, the use of water-consumption technologies and the imperfection of technical means of water management and water distribution by water consumption by sectors of the economy in the country, as well as the inconsistency of interstate water relations are the main threats and challenges in the water supply area. Water scarcity could exacerbate interstate water conflicts, development of new foci of ecological instability, and the failure of the socio-economic development programs [4].

In the current conditions, the implementation of these plans requires the application of very serious efforts, and above all, a clear understanding of the available water resources. 85 % of the water resources consumed in the Republic of Kazakhstan represent river runoff. The Institute of Geography of Kazakhstan initiated the development of a specialized scientific and technical program "Resource Assessment and Forecast of the Use of Natural Waters of Kazakhstan in terms of changes due to anthropogenic climatic factors" (2010 – 2013). This monumental study carried out by a number of organizations provides a multilateral assessment of the republic's water resources by WRBs [5-7]. Figure 2 shows a map of the *average annual river flow of Kazakhstan in mm.* However, the outcome of this colossal work does not provide for their practical significance, narrow regional use, for example, in the context of water-resource areas (WRAs) and administrative areas.

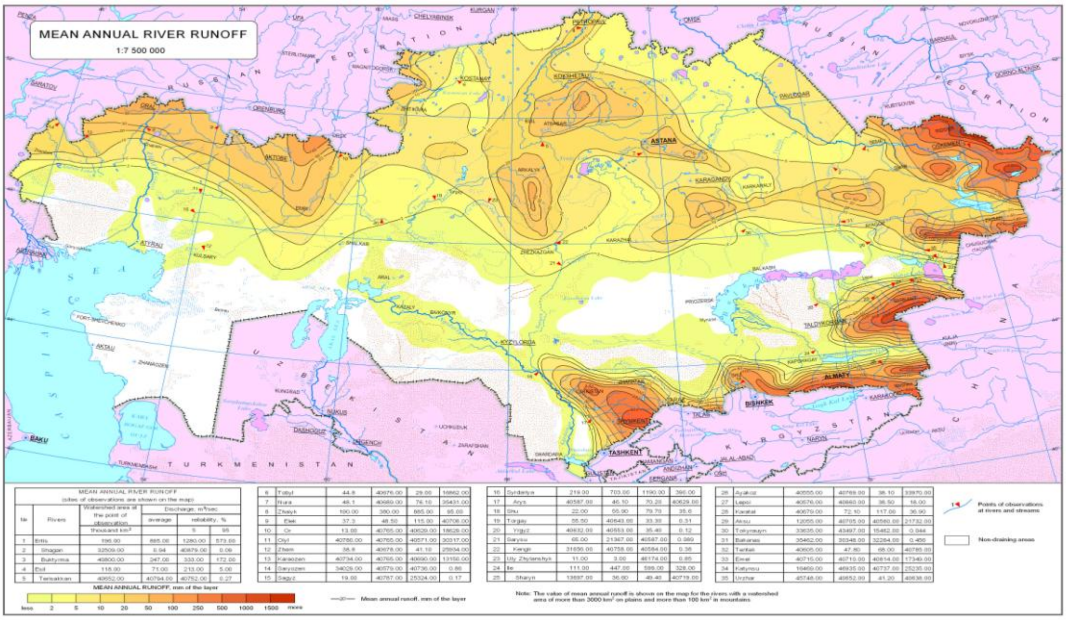

Fig.2. **The average annual layer of river runoff in Kazakhstan [**5**]**

Since the 1980s, the relevance of reliable estimates of water resources and their projected future changes under the influence of economic activity has increased even more due to the real problem of changes in the global and regional climatic characteristics. These changes have already taken place (in many regions they are very significant) and can lead to large-scale changes in the hydrological cycle, changes in water resources and their use, distribution over time and territory, and extreme characteristics of river runoff and variability thereof [1], [8], [9].

B. Algorithm

At the present stage of development of hydrological science, there are problems of methodological and theoretical assessment of renewable water resources, which do not cease to improve and be relevant, in the light of changes in the Earth's climate system and anthropogenic factors influencing river runoff.

At the first stage, the preparatory work itself was carried out, namely: the definition of research methods and calculations, the development of relevant recommendations, and the collection and analysis of baseline information.

A series of actual observations of the annual runoff for all available gauging stations for all eight water basins were processed. Monthly water flow rates (m^3/s) for all gauging stations for eight WRBs were collected in a single database and presented in the form of electronic presentation of all hydrological information on river runoff.

In Kazakhstan, the series of hydrological observations are often incomplete, contain gaps, and since the 1990s, the hydrometric network has greatly reduced. Therefore, the reconstruction of these series is a very important task. A literary search was carried out, including Russian recommendations and regulations. Original studies of the authors in terms of the use of ultrashort series for estimating the characteristics of annual runoff were drawn in and deepened [8]-[16].

The existing methods for calculating characteristics of runoff of unexplored basins and basins with short periods of observations are based on the hydrologic analogy method, with the possibility of identifying reliable analogues to unexplored rivers of the region as the key criterion.

When forming the river runoff, the factors most strongly influencing the river runoff such as climate and anthropogenic influence were identified. As is known, runoff is nonstationary and when calculating water resources, the homogeneity of the available data series calculated by parametric criteria must be taken into account.

When using ultrashort hydrological series, there are three options for calculating the average runoff: 1) based on the assumption of equality of modular coefficients of the runoff in specific years in the “design point” and in the analogue point 2) by the dependence of the average runoff on the runoff value of the specific year for the group of stations of the district built for each year; and 3) by the regression equation using the values of the spatial correlation function [14]-[16].

The analysis carried out taking into account the specific features of the Kazakh Rivers led to the conclusion that the first method was the most promising for the research. It assumes synchronism of runoff oscillations in the point under study and the analogue point, as well as equality of the parameters C_v (coefficient of variation) and C_s (coefficient of skewness). The accuracy of the calculation is increased by using together two or three analogues.

In the absence of hydrometric observations in the reference section, the average runoff is determined using the following main methods: water balance; hydrological analogy; contouring; and building regional dependencies of runoff characteristics on the main physiographic factors of the watersheds.

The geographical interpolation between the values of the average runoff in the basins of the rivers under study is the most common way to determine the average annual runoff in the absence of observations. In Kazakhstan, where the network of points with long observations is rare, the use of the specified method implies great difficulties.

In these circumstances, to calculate the annual runoff of the unexplored rivers and sites, the determination of the dependence of annual runoff from the major site-forming factors is of particular importance. In mountainous areas, where the zoning of these factors is disturbed, the method of calculating runoff based on the dependence of the water content of the rivers (M_0) on the average height of the catchment is widely used. The $M_0 = f(H_{av})$ dependence is widely used for plain Kazakhstan areas. This method was also recommended for calculating the average runoff of unexplored rivers with a catchment area of more than 3,000 sq. km using the system of dependencies of the annual average runoff on the average height of the catchment.

III. RESULT ANALYSIS

The collection and critical analysis of hydrological observations over the territory of the Aral-Syr Darya, Shu-Talas, Ile-Balkhash, Irtysh, Nur-Sarysu, Tobyl-Torgai, Zhaiyk-Caspian, and Esil WRBs were made.

The analysis of the hydrological study of all eight WRBs showed that it was insufficient for a reliable assessment of water resources, their territorial distribution, and the derivation of calculated dependencies. Short series predominate, and for up to 30 – 50 % of the series the data are available for no more than 10 years. Longer series usually contain significant gaps. On some of the stations in some years the observation was performed not in all months.

Evaluation of the average runoff. The analysis of the long-term annual runoff for the main rivers was carried out. In particular, the following techniques were used: integral (cumulative) curves, moving averaging, and the difference integral curves. As a result of the analysis, the findings of climate scientists on the new phase of the climate since the mid-1970s are generally confirmed. The beginning of the progressive global warming and directed changes in the volume of water resources of the regions refer to this moment [1], [3], [5]-[8].

When restoring the runoff of the explored rivers (with the data on the observations of the runoff for more than 6 years), the method of hydrological analogy was used, and rarely the connection between the runoff and meteorological elements (precipitation). When selecting the analogue point, the main criterion is synchronism in the fluctuations of the river runoff of the design section and the analogue section, which is expressed in terms of the pair or multiple correlation ratio [14]-[16].

Throughout the territory of Kazakhstan, there are a large number of rivers and observation points with an observation period of less than six years ($n < 6$). These are mainly the stations opened after 2000. For example, on the Zhaiyk, Zhem (Emba), Ilek, Karaozen, Saryozen Rivers and on many other rivers there are fragmentary observational data made before 1960. The rivers with observational runoff data of less than 6 years are classified as little-explored rivers. Methods for recording materials of short-term field hydrometeorological surveys provide for preliminary reducing of the weather values, parameters, and quantiles of the runoff distribution of the rivers of the studied area to a multiyear period. The runoff values for each year, the norms and quantiles of the river runoff distribution are determined using the method of relations based on the approximate equality of the modular coefficients at the point with short-term observations and in the analogue points [14]-[16]. The analogue points with regular hydrometric observations in calculations using the method based on the equality of modular coefficients are usually selected based on the smallest distance between the gravity centers of the catchments of the design point and the analogue point.

If there are several analogue points, calculations are made sequentially for all analogues, and the results are averaged (no more than three analogues) taking into account random mean square errors.

In accordance with the runoff values restoring method by the regression equations, when there is one year of short-term observations, equations are derived between all the observations for this year and consistently for all the other years in which there are observations at the analogue points, provided that there are not less than 5 – 6 points.

The areas of unexplored rivers and sections are available in all WRBs. The geographical interpolation between the values of the average runoff in the basins of the rivers under study is the most common way to determine the average annual runoff *in the absence of observations.* In Kazakhstan, where the network of points with long observations is rare in some areas, the use of the specified method implies great difficulties.

In these circumstances, to calculate the annual runoff of the unexplored rivers and sites, the determination of the dependence of annual runoff on the major site-forming factors is of particular importance. In mountainous areas, where the zoning of these factors is disturbed, the method of calculating runoff based on the dependence of the water content of the rivers ($h = f(H_{wh.av.})$ on the average height of the catchment is widely used. The $M_0 = f(F)$ dependence is widely used for plain Kazakhstan areas. This method was also recommended for calculating the average runoff of unexplored rivers with a catchment area of more than 3,000 sq. km.

The annual runoff of the Kazakhstan Rivers can be determined from the contour maps or by the regional runoff dependencies on the area or average catchment height, the values of which are provided in the "Surface Water Resources" monographs. However, the materials of the 1960s are outdated and need to be refined, taking into account the latest decades.

To date, the hydrological study of the territory has improved significantly. The differentiation of regional dependencies inevitably increases with the improvement of the territory study. However, the dependences identified by a limited number of points (especially by 2 – 3 – 4) are apparently approximate ones, but formally they are usually closer than with more information used.

The possibilities of calculating the runoff of unexplored rivers of Kazakhstan by the contour map of the annual runoff module and the dependence of this runoff on the area (for lowland rivers) and the average height (for mountain rivers) of the catchment were considered.

Sometimes it turns out that the determination of the average runoff by the $M_0 = f(F)$ dependence or from the contour map leads to a large error, as, for example, in the Zhaiyk-Caspian WRB: on the right-bank tributaries of the Zhaiyk River within the boundary of Kazakhstan, the runoff layer varies within 30 – 60 mm and has a large error. In this case, it is recommended to calculate the average runoff by two independent methods, i.e., it is advisable to simultaneously calculate the annual runoff by two independent methods, namely: using the runoff dependence on the physical-geographical factors and the runoff contour map. According to the authors, the use of the limiting catchment area of 3,000 sq. km. in the $M_0 = f(F)$ dependence in [14]-[20] is the automatic transfer of the MGI (mining-and-geological institute) results to the given area. In the area under consideration, an increase in the catchment area means an increase in the proportion of lowland areas with many closed degradations and with unfavorable geology for the formation and even transit of the runoff. It is no coincidence that in the lower parts of the Irgiz, Torgai, and Sarysu Rivers of Northern Kazakhstan, the loss of runoff begins to dominate over the tributary and the runoff is reduced, or even completely lost. Thus, the runoff reduction by area "works", and also for large areas it "works", maybe even more than for small ones. Here, the catchment area is an integral indicator of the local river runoff formation conditions. With an increase in the catchment area, the runoff value should decrease, and there is practically no upper limit of the area in this dependence.

The average runoff was estimated for all eight WRBs, including by the short series by 857 points, whereas earlier in the "Resources..." [9]-[12] 420 points had been used for this.

The average runoff for the last period (1974 – 2007) on the rivers of the south and southeast of the Republic of Kazakhstan increased by 1.7 % (Syr Darya Basin), 5.2 % (Shu-Talas Basin), and 3.0 % (Balkhash-Alakol Basin), except for the rivers of the northern coast of Lake Balkhash, where a slight runoff decrease has been observed over the last period [17]-[18].

The results of the quantitative analysis of WRBs show that the runoff of the main rivers of the northern half of Kazakhstan in the last 10 years, approximately since 1974, has decreased, in particular, the runoff of Black Irtysh and the major rivers of the Western Altai, Tobyl, Togyzak, Nury, Khobda, Oyila, as well as the rivers of the Northern Balkhash region. At the same time, on the glacier-fed stream (south and south-east of the Republic of Kazakhstan), the opposite tendency – a slight increase in the water content of the rivers – was noted. However, the interannual variability of the river runoff decreased by the absolute majority of the sections [5]-[8], [17]-[22].

In the recent period, the average runoff in the Upper Irtysh basin has been lower by 6.7 % than the multiyear one, and in the Zhaiyk-Caspian WRB, it has been lower by about 10 % (although, on the contrary, the runoff of the right bank of the Zhayik River has increased). Even more significant is the runoff decrease compared to the values published in the "Surface Water Resources". In Central Kazakhstan, this trend has not been observed, and in the Sarysu River basin, the river runoff has even increased in the last 10 years [17]-[18].

One of the objectives of this study was also a comprehensive assessment of river runoff indicators for the total of eight water basins in Kazakhstan, namely: Aral-Syr Darya, Balkhash-Alacol, Shu-Talas, Zhaiyk-Caspian, Tobyl-Torgai, Nur-Sarysu, Irtysh, in particular, the following types of work were performed: − The reconstruction of the series of the annual runoff of the explored rivers in each specific section had been carried out, and the correlation dependences and the replenished series of the annual runoff were presented, as well as annual data on runoff in the gauging station sections, including values recovered by indirect methods.

− The reconstruction of the annual runoff series of the poorly explored rivers, including ultrashort series, had been completed, and correlation dependences and replenished annual runoff series had been presented;

– Full reconstructed series of the annual runoff of the explored and poorly explored rivers had been obtained on the basis of correlation analysis;

– Recommendations had been developed for calculating the runoff of unexplored rivers and sections;

− The main hydrological characteristics of the runoff had been determined at gauging stations; and

– Recommendations had been provided for calculating the runoff of unexplored rivers and sections.

Assessment of water resources.

Renewable water resources of the basins usually consist of the runoff recorded in the closing sections of the rivers, the inflow of water below these sections, as well as the runoff of unexplored rivers. Since the runoff in the lower parts of rivers in the lowland area of Kazakhstan is usually scattered, sometimes up to complete disappearance, data on the sections with the maximum runoff were used to calculate the total water resources.

The total water resources were estimated in two scenarios: on the basis of the observed (domestic) and natural (restored) runoff. In addition, the values of local runoff, Kazakh runoff, and runoff coming from the neighboring countries were divided.

Calculation of runoff for the explored areas (based on the data of the GS). The calculations were carried out by summing up the runoff of the rivers closing the GS formation area by the WRAs. The GSs were selected based on the analysis of the channel water balance of a particular river or river basin (when the GSs were available on several tributaries), as well as a comparison of their runoff values. The GSs with the highest average annual water flows relative to other (if any) GSs along the length of the river or in the basin of a private river were taken, below which the areas have been classified as unexplored ones, despite the available GSs there. This is due to the fact that the latter are sometimes located below the sites determined by natural runoff losses.

For WRBs, the mean annual values have been obtained by summing up similar values for water-resource sites that are included in a particular basin.

Thus, the local runoff of each section is estimated as the sum of the components: the runoff recorded by observations in the gauging station sections, the runoff of unexplored rivers (based on dependencies derived and runoff maps drawn up), and the runoff from the intervening areas. Being usually located in the lower parts of river basins, for a considerable part of the time these sites can be almost endless, but in high-water years they still form a runoff, although insignificant one.

The resources entering the site from other sites – the inflows – were identified for each WRB. The amount of the inflow and local (formed on the territory of this area within the Republic of Kazakhstan) resources gives the total resources of the WRB. The calculation results are presented in Table 1 [17]-[22].

Table 1. Average Long-Term Values Of The Runoff In The Wrbs Of Kazakhstan

WRB	Inflow, km^3	Local resources, km^3	Total resources, km^3	Outflow, km^3
Aral-Syr Darya	26.5	3.28	29.4*	0.376
Shu-Talas	1.29	4.10	5.39	
Balkhash-Alacol	15.7	16.8	31.6*	0.926
Zhaiyk-Caspian	10.2	5.19	14.5*	0.808
Esil	0	2.21	2.21	1.47
Tobyl-Torgai	0.441	1.71	2.15	0.707
Nur-Sarysu	0	1.15	1.15	
Irtysh	10.3	26.4	35.2*	33.2
Note * – in order to avoid double counting, the resources formed in the territory of the Republic of Kazakhstan, which flow into the territory of neighboring states, and are then counted as inflows into the WRB, were deducted from total resources;				

On a scale of eight WRBs, both average water resources and resources in characteristic water years were estimated (50, 75, and 95 % of availability).

The total water resources of the territory of the Republic of Kazakhstan in the years of various types of runoff were determined by summing up the equipotent runoff values for all the WRBs [17]-[22].

Table 2. Natural resources of varying supply by WRBs of Kazakhstan

Resources	W, km^3	Cv	Consumption of water with varying content, km^3				
			5 %	25 %	50 %	75 %	95 %
1	2	3	4	5	6	7	8
Aral-Syr Darya WRB							
Inflow into the WRB	26.5	0.23	37.3	30.4	26.0	22.2	17.4
Local resources within WRB	3.28	0.31	4.98	3.87	3.19	2.60	1.91
Total resources by WRB	29.4	0.24	41.7	33.8	28.8	24.5	19.1
Outflow from the WRB	0.376	0.28	0.565	0.442	0.366	0.300	0.222
Shu-Talas WRB							
Inflow into the WRB	4.10	0.17	5.31	4.54	4.05	3.60	3.03
Local resources within the WRB	1.29	0.42	2.20	1.58	1.23	0.93	0.61
Total resources by WRB	5.39	0.30	7.50	6.11	5.28	4.54	3.64
Outflow from the WRB							
Balkhash-Alacol WRB							
Inflow into the WRB	15.7	0.84	26.0	17.4	15.5	13.7	11.5
Local resources within WRB	16.8	0.25	24.2	19.4	16.4	13.8	10.7
Total resources by WRB	31.6	0.43	49.0	35.8	30.9	26.7	21.6
Outflow from the WRB	0.93	0.21	1.27	1.05	0.91	0.79	0.63
Zhaiyk-Caspian WRB							
Inflow into the WRB	10.2	0.53	20.3	13.2	9.22	6.21	3.21
Local resources within WRB	5.19	0.59	11.01	6.77	4.57	2.98	1.49
Total resources by WRB	14.5	0.55	29.6	18.9	13.1	8.74	4.50
Outflow from the WRB	0.808	0.61	1.750	1.072	0.712	0.443	0.200
Esil WRB							
Inflow into the WRB	0	0	0	0	0	0	0
Local resources within WRB	2.21	0.83	5.57	3.02	1.78	0.96	0.32
Total resources by WRB	2.21	0.83	5.57	3.02	1.78	0.96	0.32
Outflow from the WRB	1.47	0.81	3.63	1.99	1.19	0.67	0.26
Tobyl-Torgai WRB							
Inflow into the WRB	0.44	0.90	1.20	0.60	0.33	0.17	0.066
Local resources within WRB	1.71	0.81	4.25	2.32	1.39	0.77	0.29
Total resources by WRB	2.15	0.85	5.44	2.92	1.72	0.94	0.36
Outflow from the WRB	0.71	0.68	1.82	0.96	0.56	0.30	0.12
Nur-Sarysu WRB							
Inflow into the WRB	0	0	0	0	0	0	0
Local resources within WRB	1.15	0.73	2.79	1.57	0.96	0.54	0.20
Total resources by WRB	1.15	0.73	2.79	1.57	0.96	0.54	0.20
Outflow from the WRB	0	0	0	0	0	0	0
Irtysh WRB							
Inflow into the WRB	10.3	0.22	21.6	19.6	18.3	17.2	15.8
Local resources within WRB	26.4	0.22	39.8	30.8	25.6	21.1	15.9
Total resources by WRB*	35.2	0.24	59.1	48.6	42.4	37.1	30.9
Outflow from the WRB	33.2	0.21	68.3	89.7	57.8	54.1	49.6
Total inflow in Kazakhstan	**67.2**	**0.40**	**111**	**85.1**	**73.1**	**62.8**	**50.9**

Retrieval Number F8626088619/2019©BEIESP
DOI: 10.35940/ijeat.F8626.088619
Journal Website: www.ijeat.org

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

Local resources within Kazakhstan	**58.0**	**0.52**	**94.8**	**69.3**	**55.1**	**43.7**	**31.5**
Total resources in Kazakhstan	**121.7**	**0.38**	**199**	**150**	**125**	**104**	**80.6**
Total outflow in Kazakhstan	**37.5**	**0.47**	**77.4**	**95.2**	**61.5**	**56.6**	**51.0**

* – in the total resources to avoid double counting, the outflow for the Tekes, Kaba, Belozek, Or, Ilek, Ogem, Maydantal rivers was not taken into account

IV. DISCUSSION

The studies have shown that on the territory of Kazakhstan the total resources of surface waters forming in Kazakhstan and coming from the areas of neighboring states are 121.7

km^3 on average, the resources formed within Kazakhstan – 58.0 km^3, and the inflow from neighboring countries such as Uzbekistan, Kyrgyzstan, Russia, and PRC is defined as 67.2 km^3. As a result, while in the 1950s, the resources of surface runoff of Kazakhstan's rivers were estimated at 150 km^3/year [23], [24], in the 70 – 80s this value was equal to 115 – 125 km^3/year [25], [26], i.e., as follows from the data above, they have decreased. At the level of 2020, taking into account the increasing water intakes from transboundary rivers, some competent authors [5]-[8], [26] predict the level of 75 km^3, with an inevitable deficit even in the average water years. In the dry years, the deficit can be more critical, and in this regard, the fact that lowland Kazakhstan is characterized by the annual runoff variability, the record one for the continent [27] and its extremely uneven intra-annual distribution also plays an important role.

Figure 3 shows the dynamics of changes in the water resources of Kazakhstan. Here, it is necessary to note the following: 1) the graph shows the data from literary sources at the level of their printing; 2) water resources were estimated by various groups of authors at different times from 1965 to 2018, and the indicators of river runoff for different periods from the beginning of the observations until 2015 were averaged; 3) the present studies provide estimates of water resources, river runoff over unexplored territories were updated and ultra-short series were extended, which had been absent in previous studies [5]-[8], including for short series of 857 points, whereas earlier in the "Resources..." [9]-[12] 420 points were used for this; and 4) the evaluation of the Institute of Geography for 2010 [5]-[8] provides information on the determination of the average runoff for the period up to 2007, after which the high-water phase in the river runoff regime has appeared, which has also significantly influenced the increase in the value of water resources by almost 10 – 12 %.

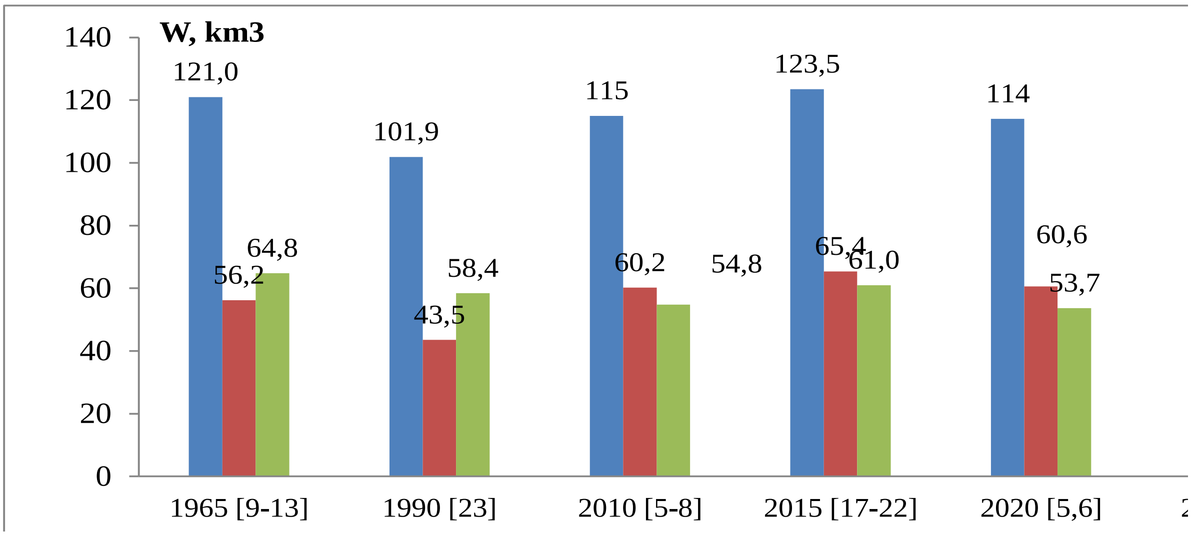

Fig.3. Water resources of Kazakhstan according to various authors

V. CONCLUSION

Thus, a methodological basis has been obtained for the reconstruction of runoff series, including the use of short and ultrashort series, as well as a methodological basis for determining the hydrological characteristics of unexplored rivers. Based on practically all accumulated hydrometric information, using the modern methodology and statistical techniques, the water resources of eight WRBs in the territory of Kazakhstan as a whole have been assessed in the following scenarios: common (observed) and natural (climatic) runoff, total and local runoff. All this was obtained for the design periods: the long-term (from the beginning to the end of the 1930s), the modern, and the previous periods, most of which were characterized by conditionally natural runoff. These materials can be considered as updated data from the "Surface Water Resources..." published in the 50 – 70s. They take into account the information accumulated over the past 40-50-years period. The data will find application in addressing strategic and current issues related to the use of water resources and management thereof in terms of quality and quantity.

ACKNOWLEDGMENTS

The present studies were carried out within the framework of the project under the Program: Scientific and technological substantiation for the efficient use of water resources with an increase in the area of regular and estuarial irrigation in all water-resource basins of the Republic of Kazakhstan until 2021. Project: The efficient use of water resources with an increase in the area of regular and estuarial irrigation in all water-resource basins of the Republic of Kazakhstan until 2021. Action: The assessment and forecast of the annually renewable water resources available for use for irrigation purposes in the water-resource basins of the Republic of Kazakhstan (KazNIIVKh RK under the contract No. 1/1 with the Institute of Geography dated September 14, 2018).

REFERENCES

1. The authoritative source of information on weather, climate and water in the United Nations system. Avaliable: https://public/wmo.int/ru
2. The "Kazakhstan-2050" Strategy: a new political course of the established state: Message of the President of the Republic of Kazakhstan – Leader of the Nation N. A. Nazarbayev to the people of Kazakhstan. Astana, December 14, 2012.
3. Diagnostic report for the preparation of a regional strategy for the rational and efficient use of water resources. Project Working Group on Energy and Water Resources, UN, ECE, February 2002, 83 p.
4. E. N. Nysanbayev, A. R. Medeu, and A. A. Tursunova, “Vodnyye resursy Tsentralnoy Azii: vyzovy i ugrozy, problemy ispolzovaniya” [Water resources of Central Asia: challenges and threats, problems of use]. Water resources of Central Asia and their use, Proceedings of the international scientific-practical conference, "Water for Life", Book 1. Almaty: Institute of Geography, LLP, 2016, pp. 4-8.
5. A. R. Medeu (Ed.). National Atlas of the Republic of Kazakhstan. Vol. 1: Natural conditions and resources, 2nd ed. revised and amended, Almaty: LLP Institute of Geography, 2010, 150 p.
6. Zh. D. Dostay, S. K. Alimkulov, and A. A. Saparova, “*Vodnyye resursy Kazakhstana: otsenka, prognoz, upravleniye. Resursy rechnogo stoka Kazakhstana. Vozobnovlyayemyye resursy poverkhnostnykh vod yuga i yugo-vostoka Kazakhstana*” [Water resources of Kazakhstan: assessment, forecast, management. Resources of river runoff of Kazakhstan. Renewable surface water resources of the south and south-east of Kazakhstan]. Vol. 7, Book 2. Almaty, 2012, 360 p.
7. Vodnyye resursy Kazakhstana: otsenka, prognoz, upravleniye. Resursy rechnogo stoka Kazakhstana. Vozobnovlyayemyye resursy poverkhnostnykh vod Zapadnogo, Severnogo, Tsentralnogo i Vostochnogo Kazakhstana [Water resources of Kazakhstan: assessment, forecast, management. Resources of river runoff of Kazakhstan. Renewable surface water resources of Western, Northern, Central and Eastern Kazakhstan]. Vol. 7, Book 1. Monograph. R. I. Galperin (Ed.). Almaty: TOO “ARKO”, 2012, 684 p.
8. Zh. D. Dostay, R. I. Galperin, S. K. Davletgaliev, and S.A. Alimkulov. Prirodnyye vody Kazakhstana: resursy, rezhim, kachestvo i prognoz [Natural waters of Kazakhstan: resources, regime, quality and forecast]. *Questions of geography and Geoecology*, 2012, vol. 4, pp. 18 – 24.
9. I. A. Ilyina (Ed.). Resursy poverkhnostnykh vod SSSR. Srednyaya Aziya. Basseyn r. Syrdari [Surface water resources of the USSR Middle Asia. Syr Sarya River Basin]. Leningrad: Gidrometeoizdat, 1969, vol. 14(1), 512 p.
10. G. G. Dobroumova (Ed.). Resursy poverkhnostnykh vod SSSR. Bassejny ozera Issyk-Kul' i rek CHu, Talas, Tarim [Surface water resources of the USSR. - Basins of the Issyk-Kul Lake, Chu, Talas and Tarim Rivers]. Leningrad: Gidrometeoizdat, 1973, vol. 14(2), 308 p.
11. B. A. Semenov, and R. D. Kurdin (Eds.). Resursy poverkhnostnykh vod SSSR. Tsentralnyy i Yuzhnyy Kazakhstan. Baseyn ozera Balkhash [Surface water resources of the USSR. Central and South Kazakhstan. Basin of the Lake Balkhash.]. Leningrad: Gidrometeoizdat, 1970, vol. 13(2), 646 p.
12. Resursy poverkhnostnykh vod SSSR [USSR Surface Water Resources]. Leningrad: Gidrometeoizdat, 1969, vol. 12–15(2), 646 p.
13. A. Shiklomanov (Ed.). Vodnyye resursy Rossii i ikh ispolzovaniye [Water resources of Russia and their use.]. St. Petersburg: GGI, 2008, 600 p.
14. SNiP 2.01.14-83. Opredeleniye raschetnykh gidrologicheskikh kharakteristik. [Determination of the calculated hydrological characteristics.]. Moscow: Stroiizdat, 1983, 36 p.
15. A. V. Rozhdestvenskij, and A. G. Lobanova. (Eds).Posobiye po opredeleniyu raschetnykh gidrologicheskikh kharakteristik [Manual to determine the calculated hydrological characteristics]. Leningrad: Gidrometeoizdat, 1984, 448 p.
16. Code of Rules SP 33-101-2003. Determination of the main calculated hydrological characteristics. Official publication. Moscow: Gosstroy of Russia, 2004, 73 p.
17. Zh. D. Dostay, S. K. Alimkulov, A. A. Tursunova, and A. A. Saparova. Otsenka resursov poverkhnostnykh vod Yuzhnogo Kazakhstana na perspektivu [Prospective surface water resources assessment of South Kazakhstan]. Second All-Russian Scientific Conference with international participation. "Water and environmental problems of Siberia and Central Asia". Barnaul, 2014, vol. 1, pp. 102 – 109.
18. S. K. Alimkulov, A. A. Tursunova, A. A. Saparova, A. R. Zigiddulina, and K. M. Kulebayev. Zakonomernosti territorialnogo raspredeleniya resursov rechnogo stoka yuga i yugo-vostoka Kazakhstana v sovremennykh usloviyakh razvitiya geograficheskoy sredy [Patterns of territorial distribution of river flow resources in the south and south-east of Kazakhstan in the modern conditions of the development of the geographical environment]. *Questions of geography and geoecology*, 2016, vol. 1, pp. 23 – 30.
19. S. K. Davletgaliyev. Prognoz vodnykh resursov Uralo-Kaspiyskogo basseyna [Forecast of water resources of the Ural-Caspian basin]. *Hydrometeorology and Ecology*, 2015, vol. 1(76), pp. 115 – 120.
20. S. K. Davletgaliyev. Otsenka kharakteristik godovogo stoka neizuchennykh rek Zhayyk-Kaspiyskogo vodokhozyaystvennogo basseyna [Estimation of the characteristics of the annual flow of the unexplored rivers of the Zhaiyk-Caspian water basin]. *Hydrometeorology and Ecology*, 2016, vol. 1(80), pp. 60 – 66.
21. M. M. Moldakhmetov, L. K. Makhmudova, and A. G. Chigrinets, “Evaluation of the water resources of the rivers in North, Central and Eastern Kazakhstan, based forecasting meteorological characteristics”. Materials of International Conference "Science: Integrating Theory and Practice", February 23 – 24, 2014. Bozeman, MT, USA: ICET, 2014, pp. 281 – 284.
22. M. M. Moldakhmetov, L. K. Makhmudova, and G. M. Kambarbekov. Torǵaı jáne Yrǵyz ózenderi aǵyndysynyń keńistiktik-ýaqyttyq taralý zańdylyǵynyń erekshelikteri [Features and regularities of spatial-time distribution of flow of rivers in the Turgai and Irgiz]. *Hydrometeorology and ecology*, 2016, vol. 2, pp. 86 – 94.
23. N. N. Palgov, “Reki Kazakhstana” [Rivers of Kazakhstan.]. Alma-Ata: Publishing house of the Academy of Sciences of the Kazakh SSR, 1959, 100 p.
24. P. F. Lavrentyev, and L. D. Lavrentyeva, “*Vodnyye resursy Kazakhstana*” [Water Resources of Kazakhstan]. Uchpedizdat, 1961, 588 p. Problems of hydropower and water management: in coll. scientific papers... Alma-Ata: Nauka, 1976, Issue 13.
25. I. N. Teplyakov, P. F. Lavrentyev, and S.A. Abildin, “*Vodnye resursy Kazakhstana i ikh ispolzovanie (analiticheskii obzor)*” [Water resources of Kazakhstan and their use (analytical review)]. Alma-Ata: KazNIINTI, 1978.
26. A. K. Kenshimov, S. R. Ibatullin, and A.K. Zaurbek. Problemy ispolzovaniya vodnykh resursov v Respublike Kazakhstan [Problems of water resources use in the Republic of Kazakhstan].*Water Management of Kazakhstan*, 2005, vol. 4, pp. 229 – 233.
27. A. I. Shiklomanov. Mirovyye vodnyye resursy [World water resources]. Nature and resources, 1991, vol. 20(1–2), pp. 81-91.