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ҰЛТТЫҚ ҒЫЛЫМ
АКАДЕМИЯСЫ» РҚБ

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ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ» РҚБ

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ИЗВЕСТИЯ

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THE INFLUENCE OF CLIMATIC AND ANTHROPOGENIC FACTORS ON THE HYDROLOGICAL REGIME OF THE BASINS OF THE SHU-TALAS RIVERS

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Abstract. The article examines the influence of climatic and anthropogenic factors on the formation of the hydrological regime of the rivers of the Shu-Talas water management basin using statistical methods and total difference integral curves. A graphical-analytical method for constructing the integral annual water flow is considered. All hydrological and meteorological calculations were performed using spread sheet 2000 and charting using linear trend and in rectangular coordinates were performed in the Microsoft Excel program. Based on the study, it was revealed.

Based on the study, it was revealed that on the rivers of the Shu-Talas water management basin, changes in the difference-integral curves along the Talas river

have a positive trend, followed by a decrease (until 1990) and a further increase (until 2010), with a downward change to the present. According to Shu river, there is a positive trend (until 1960) followed by a decrease (until 1985) and a further increase (until 2005) with a decrease to the present. The regime of the studied territory is determined not only by climatic changes, but also, to a large extent, by the intensity of human economic activity.

Assessment of the impact of climatic and anthropogenic factors, the development of adaptive water management systems is necessary to ensure water security and preserve river ecosystems.

Keywords: Shu-Talas reservoir, difference-integral curve, average annual runoff, linear trend, modular coefficient

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ШУ-ТАЛАС СУ ШАРУАШЫЛЫҒЫ БАССЕЙНІ ӨЗЕНДЕРІНІҢ ГИДРОЛОГИЯЛЫҚ РЕЖИМІНЕ КЛИМАТТЫҚ ЖӘНЕ АНТРОПОГЕНДІК ФАКТОРЛАРДЫҢ ӘСЕРІ

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Аннотация. Мақалада статистикалық және жиынтық айырмалық интегралдық қисықтар әдістерін пайдалана отырып, Шу-Талас су шаруашылығы бассейні өзендерінің гидрологиялық режимін қалыптастыруға климаттық және антропогендік факторлардың әсері қарастырылады. Жылдық интегралды су ағынын құрудың графоаналитикалық әдісі қарастырылған. Барлық гидрологиялық және метеорологиялық есептеулер 2000 электрондық кестесінде орындалды, сызықтық трендті қолдана отырып және тікбұрышты координаттарда графиктер Microsoft Excel бағдарламасында жасалды. Зерттеу

негізінде Шу-Талас су шаруашылығы бассейнінің өзендерінде Талас өзені бойындағы айырмашылық-интегралдық қисықтардың өзгерістері оң үрдіске ие, кейіннен төмендеу (1990 жылға дейін) және одан әрі ұлғаю (2010 жылға дейін), осы уақытқа дейін төмендеу жағына қарай өзгеретіні анықталды. Шу өзенінде оң үрдіс байқалады (1960 жылға дейін), содан кейін төмендеу (1985 жылға дейін) және одан әрі өсу (2005 жылға дейін), осы уақытқа дейін төмендеу. Зерттелетін аумақтың режимі тек климаттық өзгерістермен ғана емес, сонымен бірге адамның экономикалық белсенділігінің қарқындылығымен де анықталады. Климаттық және антропогендік факторлардың әсерін бағалау, суды басқарудың адаптивті жүйелерін дамыту су қауіпсіздігін қамтамасыз ету және өзен экожүйелерін сақтау үшін қажет.

Түйін сөздер: Шу-Талас су шаруашылығы бассейні, айырмашылық-интегралдық қисық, жылдық орташа ағын, сызықтық тренд, модульдік коэффициент.

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ВЛИЯНИЕ КЛИМАТИЧЕСКИХ И АНТРОПОГЕННЫХ ФАКТОРОВ НА ГИДРОЛОГИЧЕСКИЙ РЕЖИМ РЕК ШУ-ТАЛАССКОГО ВОДОХОЗЯЙСТВЕННОГО БАССЕЙНА

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Аннотация. В статье рассматривается влияние климатических и антропогенных факторов на формирование гидрологического режима рек Шу-Таласского водохозяйственного бассейна с использованием методов

статистического и суммарных разностных интегральных кривых. Рассмотрен графоаналитический способ построения интегрального годового расхода воды. Все гидрологические и метеорологические расчеты выполнены по электронной таблице 2000 и построение графиков с использованием линейного тренда и в прямоугольных координатах были произведены в программе Microsoft Excel. На основе исследования выявлено, что на реках Шу-Таласского водохозяйственного бассейна изменения разностно-интегральных кривых по реке Талас имеет положительный тренд с последующим уменьшением (до 1990 года) и дальнейшее увеличение (до 2010 года), с изменением в сторону уменьшения до настоящего времени. По реке Шу наблюдается положительный тренд (до 1960 года) с последующим уменьшением (до 1985 года) и дальнейшее увеличение (до 2005 года) со снижением до настоящего времени. Режим исследуемой территории определяется не только климатическими изменениями, но и в значительной степени, интенсивностью хозяйственной деятельностью человека. Оценка влияния климатических и антропогенных факторов, разработка адаптивных систем управления водными ресурсами необходима для обеспечения водной безопасности и сохранения речных экосистем.

Ключевые слова: Шу-Таласский водохозяйственный бассейн, разностно-интегральная кривая, среднегодовой сток, линейный тренд, модульный коэффициент

Introduction. The drainage area of the Shu-Talas water management basin, as a model of multifunctional river basins with diverse natural and climatic areas as mountainous, foothill, foothill-plain, plain, and desert geographical zones perform important environment-forming or ecological function. The region's renewable water resources are formed in the mountainous ecosystems of the Tien Shan and Pamirs due to the melting of seasonal snow covers and glaciers. This is referred to the global problem of climate change and was considered in the UN Framework Convention on Climate Change and adopted at the Earth Summit in Rio de Janeiro in 1992. Climate as a long-term regime of weather factors inherent in the geographical zones of the Planet that perform special functions are runoff formation, biomass production, soil formation and human habitat, has direct and feedback connections in natural processes that require analysis and assessment on a spatiotemporal scale.

Materials. The territory of the Shu-Talas water management basin is formed by the Shu, Talas and Assa rivers. Its total area is 64.5 km2, including the administrative territories of the Kochkor district of the Shu region and the Naryn district of the Talas region of the Kyrgyz Republic, as well as the Zhambyl region and the Sozak district of the Turkestan region of the Republic of Kazakhstan.

The Shu river flows west of the basin of Lake Issyk-Kul and is the largest in the Northern Tien Shan, its length is 1067 km, the basin area is 62500 km^2. It is formed at the confluence of the Dzhuvanaryk and Kochkor rivers, originating from glaciers in the Kyrgyz and Terskey-Alatau ridges (Ibatullin, et. al, 2005). The flat

surface of the Shu depression gradually decreases from 1300 m in the east to 120 m in the west. The morphological boundary of the Shu depression from the south is the Kyrgyz ridge (4894 m) and the hilly sandy plain of Moyynkum, which drops in the west from 660 to 200 m. In the north there are echelon ridges and peneplenized mountains that change each other and descend in the north-west direction (the western end of the Zailiyskiy Alatau, Zhetyzhol, Kendyktas, Shu-Ili mountains, Mayzharylgan) and the Betpak-Dala plain (Adilbektegi, et. al, 2004).

The drainage area of the Assa-Talas river basin is located in the north-west of the Kyrgyz Republic and south-west of the Republic of Kazakhstan. The Talas river is formed at the confluence of the Karakol and Uchkoshoy rivers, formed at the junction of the Kyrgyz and Talas ranges, and in the lower reaches it is lost in the sands of Moyynkum. The length of the Talas river is 661 km, the drainage basin area is 52,700 km². The Assa river originates from the confluence of the Kurkureu-Su rivers, originating on the northern slope of the Talas Alatau and Ters, formed on the southeastern slope of the Asa Karatau, whose length is 253 km and the drainage area is 6670 km2, is a left tributary of the Talas river and flows into desert reservoir in the Moyynkum sands (Mustafaev, et. al, 2023; Zhaparkulova, et. al, 2021).

To forecast modern climate changes and their manifestation in the Shu-Talas water basin watershed, a research base has been created based on long-term information and analytical materials of RSE "Kazhydromet" and "Kyrgyzhydromet", World Meteorological Organization (WMO) and reference and information portal "Weather and Climate" on meteorological stations Nurlykent, Saudakent, Talas, Oyik, Baitik and Tole bi allowing to study trends in spatial and temporal scale (Table 1).

Table 1 - Climatic indicators of the Shu-Talas water basin territory from 1970 to 2020

Years	Meteorological station					
	Assa river basin		Talas river basin		Shu river basin	
	Nurlykent	Saudakent	Talas	Oyik	Baitik	Tole bi
1	2	3	4	5	6	7
Average annual air temperature (t), °C						
1980	8,6	10,4	9,1	10,4	7,4	10,3
1981	7,7	11,0	8,5	10,7	6,7	10,4
1982	7,8	10,2	8,2	10,2	6,5	9,9
1983	8,6	12,2	9,1	11,8	7,5	11,0
1984	6,4	9,3	6,6	8,6	5,3	8,2
1985	7,6	10,2	8,3	9,7	7,0	9,6
1986	7,9	10,7	8,5	10,7	6,6	9,9
1987	8,1	10,9	8,7	11,0	6,6	10,4
1988	8,3	10,9	9,0	10,6	7,1	9,9
1989	7,3	11,0	7,7	10,7	6,0	9,8
1990	8,4	11,1	8,9	10,7	7,0	10,6
1991	8,1	10,7	8,3	10,7	6,7	10,0
1992	7,8	10,5	8,4	10,6	6,6	10,9
1993	7,1	9,2	7,4	9,3	5,7	9,1

1994	8,1	10,1	7,6	10,1	6,7	9,5
1995	8,3	12,1	8,6	12,6	6,8	10,4
1996	7,0	10,3	7,8	11,3	5,6	9,3
1997	8,7	12,0	9,4	13,0	7,2	11,2
1998	7,9	10,4	8,8	11,2	7,0	10,3
1999	8,3	11,7	9,0	12,4	6,9	11,3
2000	8,7	12,3	9,2	13,4	7,0	11,9
2001	8,8	11,5	9,3	11,4	6,3	10,8
2002	8,6	11,8	9,1	12,0	6,9	11,3
2003	7,9	10,5	8,8	11,0	6,4	10,5
2004	8,7	12,3	9,5	12,8	7,4	11,7
2005	8,0	12,0	9,2	12,2	6,9	10,8

Continued of the table 1

1	2	3	4	5	6	7
2006	8,6	11,3	9,5	11,5	6,8	10,9
2007	8,5	11,7	9,4	11,7	7,2	10,8
2008	8,3	11,1	9,1	11,0	7,1	10,4
2009	8,1	11,3	8,8	11,4	6,9	10,7
2010	8,6	11,8	9,3	11,4	7,4	10,7
2011	7,6	10,2	8,4	10,1	6,4	9,9
2012	7,0	10,2	8,1	9,8	6,5	9,2
2013	9,1	12,3	9,2	12,3	7,3	11,3
2014	6,7	9,6	8,1	9,5	6,1	8,7
2015	8,8	11,9	9,4	12,1	7,4	11,6
2016	9,2	12,1	9,8	12,1	7,6	11,5
2017	8,3	11,0	9,3	11,2	7,2	10,5
2018	7,7	10,6	8,9	10,1	6,6	9,6
2019	9,4	11,9	10,1	12,4	7,5	11,5
2020	8,0	11,3	8,6	11,4	6,4	10,3
Annual precipitation (0_c),mm						
1970	425	216	331	235	633	767
1971	392	198	243	215	478	296
1972	563	231	340	252	615	390
1973	294	176	344	190	436	52
1974	430	147	379	157	495	20
1975	328	152	312	162	483	72
1976	437	197	392	213	511	94
1977	494	161	372	173	500	196
1978	611	247	321	266	489	354
1979	497	202	372	219	577	295
1980	424	176	270	201	537	268
1981	449	183	279	197	752	303
1982	319	140	278	162	525	225
1983	322	163	285	145	590	247
1984	410	144	250	125	516	225
1985	393	171	285	183	525	350

1986	392	141	256	145	536	272
1987	521	186	376	201	571	382
1988	503	187	336	202	573	323
1989	383	154	306	165	543	251
1990	398	228	331	249	514	230
1991	399	174	285	187	536	265
1992	406	238	284	260	541	94
1993	688	509	420	568	547	145
1994	540	278	331	306	549	132
1995	400	165	152	196	552	138
1996	449	226	266	248	557	330
1997	426	213	156	237	561	270
1998	591	277	546	292	559	268
1999	590	221	342	244	562	273
2000	447	207	315	232	568	245

Continued of the table 1

1	2	3	4	5	6	7
2001	451	138	289	147	574	257
2002	580	147	494	157	555	393
2003	616	190	475	206	529	490
1	2	3	4	5	6	7
2004	458	218	337	241	520	267
2005	505	213	278	237	512	258
2006	466	120	277	126	505	294
2007	343	224	299	247	501	279
2008	349	91	248	93	495	287
2009	435	204	314	229	490	238
2010	600	260	444	277	486	351
2011	487	146	353	155	482	345
2012	458	72	186	72	409	187
2013	588	87	361	88	451	330
2014	601	87	273	89	425	334
2015	458	155	305	166	398	424
2016	588	182	510	196	363	470
2017	602	155	305	166	423	386
2018	379	113	276	118	431	330
2019	337	108	257	112	394	273
2020	297	140	200	81	378	259

The table shows that temperature increased for the period from 1970 to 2020 in the basins of the Assa river by 0.7°C, Talas - 1.5°C, Shu - 0.7°C on average and precipitation decreased in the Shu-Talas basin according by 102 mm, 142 mm, 382 mm.

To solve the problems of sustainable water resource management at the catchment level of transboundary rivers of the Shu-Talas water basin, it is necessary to study

the dynamics of river flow under the influence of climatic and anthropogenic factors in the formation of river flow in a changing climate.

Predicting the impact of climate change and anthropogenic activities on the hydrological regime of rivers is very difficult; one can only judge in general terms how water systems may respond to a particular climate warming scenario and anthropogenic loads. This is due to the fact that the impact on the formation of water resources in the drainage areas of river basins is determined by many multidirectional processes and their complex impact on the hydrological regime is difficult to predict.

This functional activity of climate determines the scientific and practical feasibility of studying climate change trends to identify their beneficial and negative impacts, taking into account the interests of the formation and the use of water resources in river basins (Mustafaev, et. al, 2019; Zhaparkulova, et. al, 2019; Kaliyeva,et. al, 2021; Bazhanova, et. al, 2020).

For sustainable management of water resources of transboundary rivers of the Shu-Talas water management basin, the dynamics of river flow was studied.

Methods

To analyze and identify the influence of natural and anthropogenic factors on the hydrological regime of rivers in the drainage area of the Shu-Talas water management basin, a statistical method was used, that makes it possible to approximately assess their homogeneity for the period under consideration using a graph-analytical method, by constructing total integral curves of the average annual water flow, that were produced in Microsoft Excel program.

For spatiotemporal assessment of long-term fluctuations in the annual river flow of the Shu-Talas watershed, it seems possible to use a number of hydrological calculation methods based on mathematical statistics (Shiklomanov, 1985; Vagapov, et. al, 2021; Vagapova, et. al, 2024; Mustafaev, et. al, 2019; Dobrovolsky, et. al, 2005; State water cadastre, 1997, 2005, 2015).

- the total integral curve of the average annual water flow - the sequence of increasing values of the average annual water flow for the period under consideration (n), that is, $\sum_{i=1}^{n} Q_i$, to identify natural and anthropogenic factors on the hydrological regime of rivers.

- difference integral runoff curve, which is the increasing sum of deviations of the modular coefficients of the average annual water flow from the average long-term value of the time series at the end of each year, that is, $\sum_{i=1}^{n}(k_i - 1)$ (where k_i is modular coefficients, that are calculated by the expression: $k_i = Q_i/Q_{cp}$, where Q_{cp} is the arithmetic mean value of a series of average annual water flows, determined by the formula (Dobrovolsky et. al, 2005): $Q_{cp} = \sum_{i=1}^{n} Q_i/n$, here *n* is the number of series members characterizing cyclic fluctuations of the average annual river water flow;

- probability curve (probability of exceeding) is an integral curve showing the probability of exceeding (in % or in fractions of units) a random variable among the

total population of the series: $P = [m/(n+1)]$, where m is the serial number of the values in the series under consideration; n is the number of values in the series or the number of years of observations of the characteristic in question.

To analyze and identify the influence of natural and anthropogenic factors on the hydrological regime of rivers in the drainage area of the Shu-Talas water management basin, a statistical method was used that makes it possible to approximately assess their homogeneity for the period under consideration using a graph-analytical method, by constructing total integral curves of the average annual water flow that were produced in Microsoft Excel program.

Based on the total integral curves of the average annual water flow, it is determined approximately by the turning point of the time series for the period under consideration by drawing a tangent straight line characterizing the sequence of increase in the average annual river water flow from the beginning of the period under consideration (Kaliyeva, et. al, 2021; Shiklomanov, et. al, 1985; Vagapov, et. al, 2021; Vagapova, et. al, 2024).

At the same time, the tangent, to a certain extent, characterizes the sequence of increase in the natural average annual water flow of rivers, and the straight line connecting the beginning and end of the period under consideration on the total integral curve characterizes the sequence of increase in the anthropogenic average annual water flow. Based on their difference, an increase or decrease in the average annual water flow of the period under consideration is determined.

Results and discussion

Analysis of the total integral curves of the average annual river water flow in the drainage areas of the Shu-Talas water management basin showed (Figures 1-3) that the time series of average annual flow for the period under consideration 1940-2020 can be divided into two quasi-homogeneous sets with a breaking point characterizing the transition from natural on anthropogenic activities in river basins.

In the Assa river basin, the total integral curve of the average annual water flow of the Kurkureu-Su - Maimak river is a relatively straight line until 1985 (Figure 1) that characterizes the stability of the formation of hydrological flow, and since 1986 there has been a violation of the uniformity of the average annual water flow of the river that associated with the intensive use of water resources for irrigation of agricultural land, and along the Assa – Maimak river), disturbances in the uniformity of the average annual water flow of the river were observed since 1980 (Figure 1)that is associated with the construction of the Ters-Ashibulak seasonal regulation reservoir on the Ters river.

In the Talas river basin, only at the site of the Kirov hydrological post, the total integral curve of the average annual water flow was an ideal straight line until 1980 (Figure 2), and since 1981, in connection with the construction of the Kirov reservoir for long-term regulation, there was a violation of the uniformity of the average annual water flow, while at the hydrological posts of Zhasorkenet there is no sharp violation of the uniformity of the average annual water flow, which

indicated its stability for the period 1940-2020 (State water cadastre. al, 2005; State water cadastre. al, 2015).

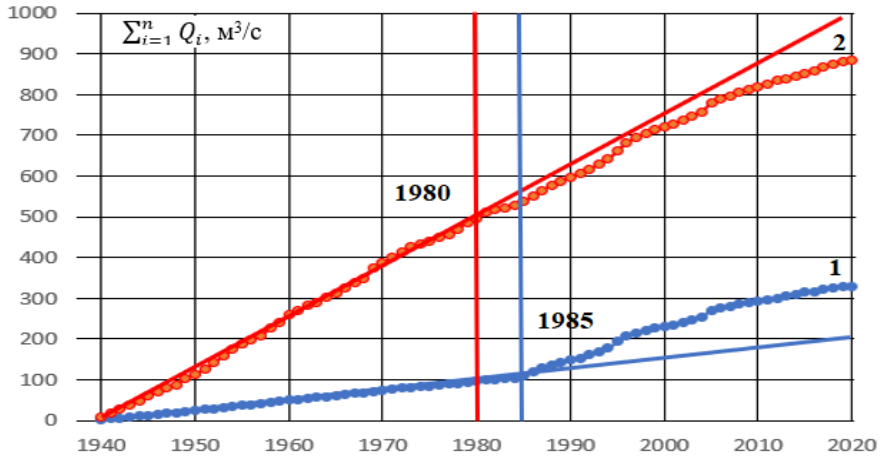

Figure 1 - Total integral curves of average annual flow rates of the Kurkureu-Su - Maimak river (1) and the river. Assa - Maymak (2)

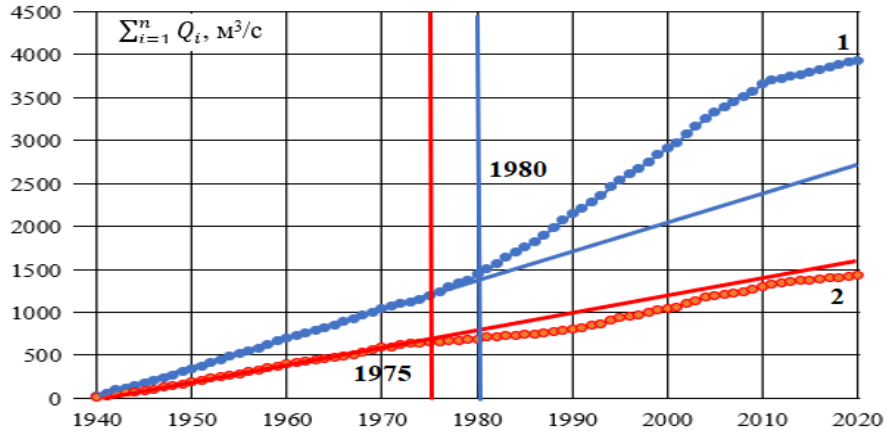

Figure2-Total integral curves of average annual flows of the Talas river at hydrological stations Kirovskoye (1) and Zhasorkenet

In the Shu-Milyanfan river basin, the total integral curve of average annual water flows is an ideal straight line, despite the regulation of flow by the Orto-Tokoy reservoir (Figure 3) from 1940 to 2020, some changes occurred that did not clearly characterize a violation of the natural regime, and at the Tasotkel hydrological station until 1975, the uniformity of the average annual water flow was maintained, and subsequently an anthropogenic hydrological regime was formed, which depended on the operational regime of the Tasotkel reservoir.

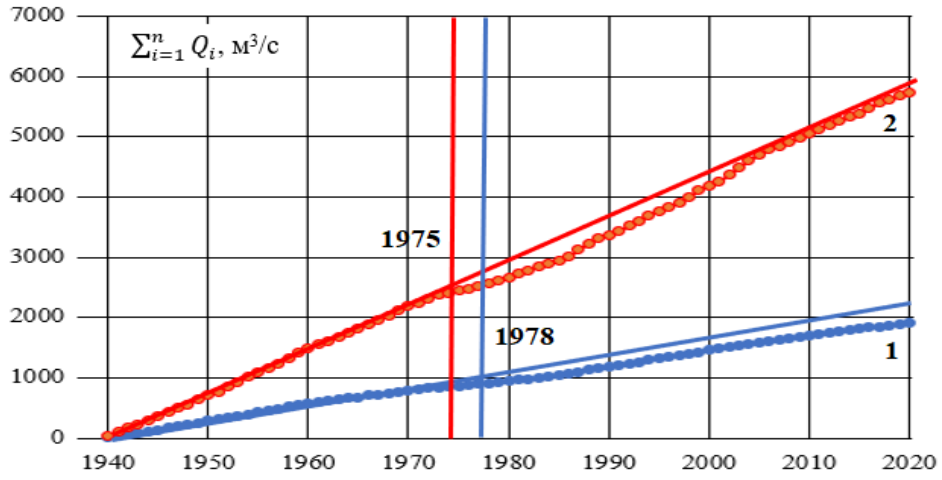

Figure3 - Total integral curves of average annual flows of the Shu River at hydrological stations Milyanfan (1) and Tasotkel (2)

In order to assess the changes in the water content of rivers in the catchment area of the Shu-Talas water management basin and the synchronism or asynchrony of long-term fluctuations, difference integral curves of modular runoff coefficients, average annual air temperature and precipitation were constructed using the methods of difference-integral curves (Figure 4).

Analysis of the difference-integral curves for the period 1940-2020 showed that the average annual flow of the Kurkureu-Su - Maimak river from 1940 to 1985 the inclined curve was negative, which characterizes a decrease in the average annual flow of the river; from 1986 to 2005 there was an increase in flow (Curve 1) , and then from 2006 to 2020 there was a decrease.

On the Assa-Maimak river, located below the Ters-Ashibulak reservoir, from 1940 to 1995 there was a smooth slope of the curve with a positive trend that indicated an increase in flow, and from 1996 to 2020, there was a smooth slope of the curve towards a negative trend, which corresponds to decrease in river flow (Curve 2).

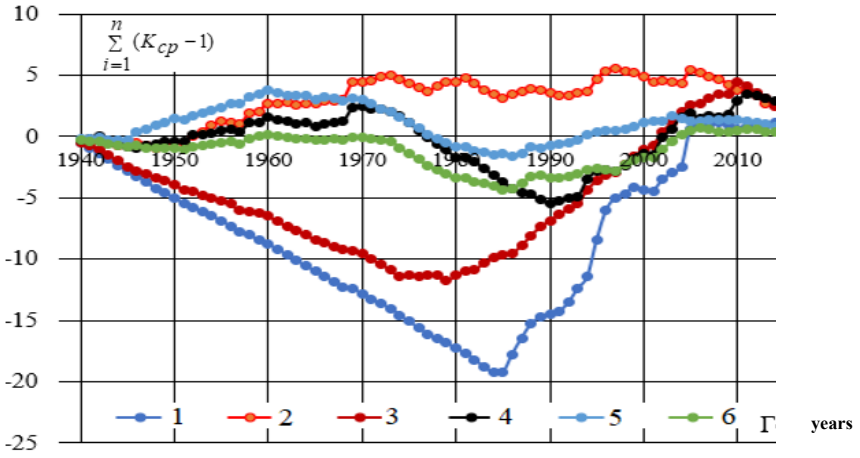

Figure4– Difference-integral curves of average annual river flows. Kurkureu-Su - Maimak (1), Assa river - Maimak (2), Talas river - Kirovskoe (3), Talas river - Zhasorkenet (4), Shu river - Milyanfan (5) and Shu river - Tashotkol (6)

The change in the quantitative values of the difference-integral curves of the Talas river basin at the Kirovskoye section for 1940-2020 showed that from 1940 to 1980 the average annual flow had a negative trend, characterizing a decrease in flow in this period of time, and from 1981 to 2010 the slope line of the average annual flow had a positive trend (curve 3), showing an increase in flow with a subsequent decrease until 2020; its nature coincides with the difference-integral curve of the Curkureu-Su river.

At the hydrological post Zhasorkenet, below the Kirov reservoir, in the Talas river basin, in the period from 1940 to 1970 there is a positive trend (curve 4), and from 1971 to 1990 the flow gradually decreased, from 1991 to 2010 it increases, and then from 2011 to 2020 the river flow decreased again.

The shapes of the difference-integral curves of the Shu river runoff at the sections of the Milyanfan (curve 5) and Tasotkol (curve 6) hydrological posts for 1940-2020 were the same, from 1940 to 1960 there is was an increase in runoff, from 1961 to 1985 - a decrease, from 1986 to 2005 - again an increase and from 2006 to 2020 a decrease again, the curves differ only in the quantitative values of the ordinates of the difference-integral curves.

It should be noted that the current situation on the rivers of the Shu-Talas water management basin is explained by the nature of the change in the difference-integral curves of the average annual air temperature at the meteorological stations Nurlykent, Saudakent, Talas, Oyyk, Baytik and Tole bi, which have the same slope curves of the average annual air temperature, and namely: from 1940 to 1985 - a negative trend, and from 1986 to 2020 - a positive trend, with different quantitative values of average annual air temperature, promoting intensive melting of glaciers and solid precipitation in the runoff formation zone.

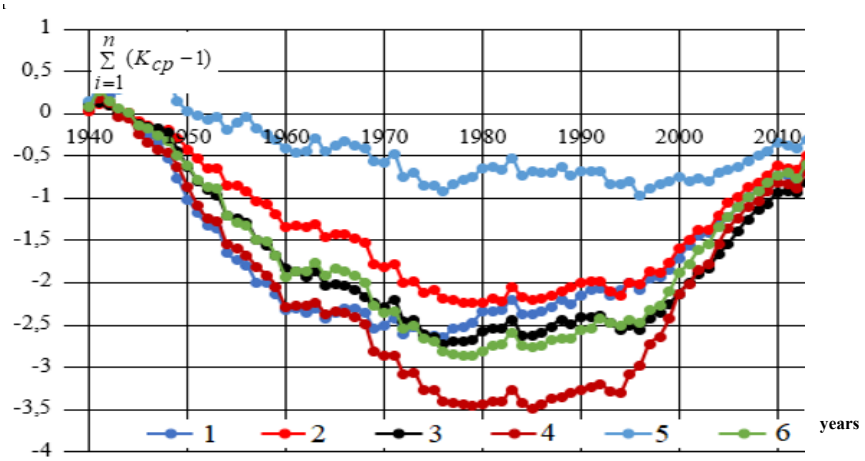

Figure 5 – Difference-integral curves of mean annual air temperature from data of meteorological stationsNurlykent (1) and Saudakent (2) in the Assa river basin, Talas (3) and Oyik (4) in the Talas river basin, Baitik (5) and Tole Bi (6) in the Shu river basin

In the catchment areas of the Shu-Talas water basin, the change in the shape of difference-integral curves of annual precipitation according to the data of meteorological stations Nurlykent, Saudakent, Talas, Oyik, Baitik and Tobebi, for 1940-2020 years, is characterized by the same slope of precipitation coefficients, differing among themselves only in quantitative values: from 1940 to 1942 had a positive trend, from 1943 to 1950 - negative, from 1951 to 1973 - positive, from 1974 to 1990 - negative, from 1991 to 2000 - positive and from 2001 to 2020 - negative, which indicates a significant variation, (Figure 16,5).

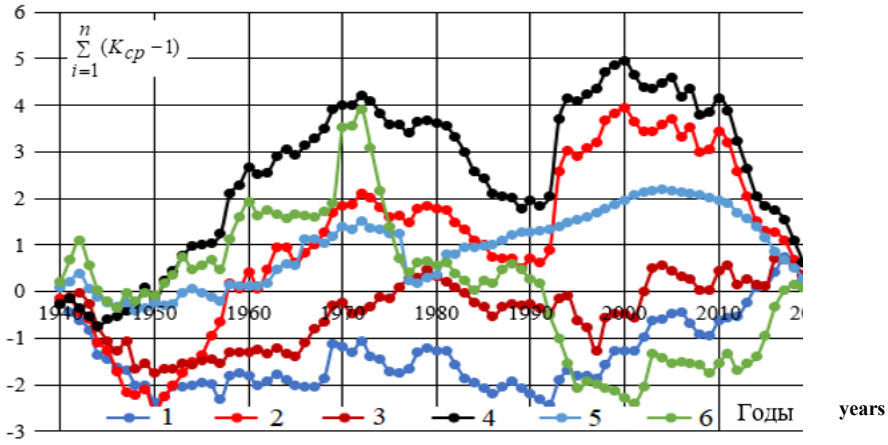

Figure 6 – Difference-integral curves of annual temperature, precipitation from data of meteorological stations Nurlykent (1) and Saudakent (2) in the Assa river basin, Talas (3); Oyik (4) in the Talas river basin, Baitik (5) and Tole bi (6) in the Shu river basin

The study of spatial and temporal regularities of river runoff formation, average annual air temperatures and annual precipitation in the catchment areas of the rivers of the Shu-Talas river basin using difference-integral curve methods showed that in the Assa river basin, upstream of the Ters-Ashchybulak reservoir, in the Talas river basin upstream of Kirov reservoir and in the Shu river basin upstream of Orto-Tokoy reservoir, the hydrological regime of rivers is formed under the influence of natural factors, and in the lower reaches - under the influence of natural-anthropogenic factors, which should be taken into account when developing the water resources management system for transboundary watercourses. To establish the regularities of fluctuations of mean annual discharge in the Assa-Talas river basin were applied the supply curves characterizing the probability of exceeding the considered value in a multiyear series and parameterization of their statistical characteristics based on the coefficients of variation (C_v) and asymmetry (C_s) (figure 6) (Goroshkov et. al, 2014):

$$C_v = \sqrt{\sum_{i=1}^{n} (K_i - 1)^2/(n-1)};$$

$$C_s =.$$

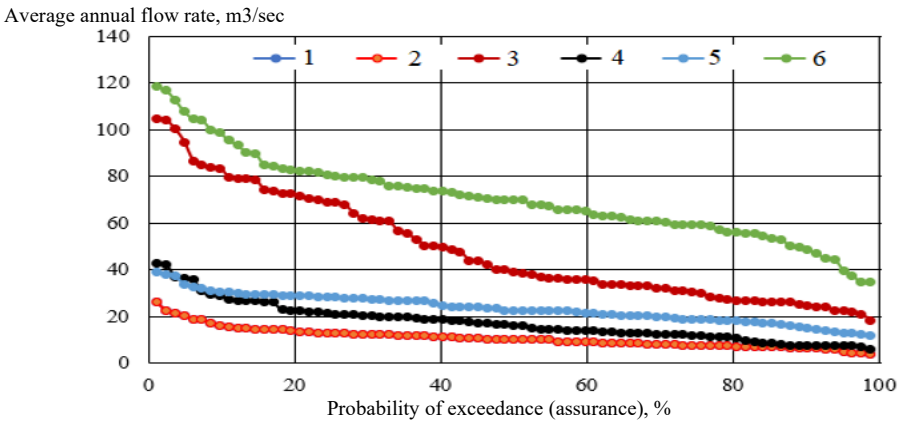

Figure 7 – Empirical curves of annual mean discharge availability of the Assa-Maimak river (1), Kurkureu-Su-Maimak river (2), Talas river at Kirovskoye (3), Jasorkent (4), Shu river at Milyanfan (5) and Tasotkel (6) gauging stations

The function of distribution of average annual water discharge of the Assa-Maimak river, Kurkureu-Su-Maimak river, Talasna river at Kirovskoye and Zhasorkenet gauging stations, Shu river at Milyanfan and Tasotkel gauging stations is a transformation of a random measured characteristic into a new one, distributed according to a known probability law, described by an exponential or polynomial equation of the fifth order, differing in a set of variables (figure 7).

Conclusion

Based on the results of studies aimed at identifying the influence of climatic and anthropogenic factors on the formation of the hydrological regime (average annual flow) of the rivers of the Shu-Talas water management basin, it can be stated that the trends in the changes in the hydrological regime of the study area depend not only on climatic changes, which are an uncontrollable factor in the natural process, but also, to a large extent, determined by the intensity of human economic activity on a spatiotemporal scale in river catchment areas, they make it possible to assess the influence of climatic and anthropogenic factors, to develop adaptive water resource management systems in order to ensure human water security and preserve the functioning conditions of river ecosystems.

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