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MODERN PROBLEMS OF INTEGRATED USE OF WATER AND ENERGY RESOURCES OF THE ARAL SEA BASIN

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Abstract. *Due to the extensive development of irrigated agriculture in the 2nd half of the last century, all the available water resources were almost completely exhausted in the Aral Sea basin. This led to the death of the Aral Sea, land degradation and conflict of interest between the countries of the region. This conflict has been further aggravated by the development of hydropower, which uses the same water resources. Despite all the efforts undertaken in the past 30 years, both by the basin countries themselves and by international organizations, it has so far not been possible to achieve any tangible positive results in resolving these conflicts. The article discusses the current situation in the water sector of the Aral Sea basin, analyzes existing problems and provides suggestions for solving them.*

Keywords: *conflict of interest, demography, energy, environmental disaster, hydropower, irrigation, population growth, water resources.*

Абстракт. *В связи с экстенсивным развитием орошаемого земледелия во второй половине XX в. все имеющиеся водные ресурсы в бассейне Аральского моря были практически полностью исчерпаны. Это привело к гибели Аральского моря, деградации земель и конфликту интересов между странами региона. Этот конфликт еще больше усугубился развитием гидроэнергетики, которая использует те же водные ресурсы. Несмотря на все усилия, предпринятые за последние 30 лет как самими странами бассейна, так и международными организациями, до сих пор не удалось достичь каких-либо ощутимых положительных результатов в разрешении этих конфликтов. В статье рассматривается текущая ситуация в водном секторе бассейна Аральского моря, анализируются существующие проблемы и даются предложения по их решению.*

Ключевые слова: *конфликт интересов, демография, энергетика, экологическая катастрофа, гидроэнергетика, ирригация, прирост населения, водные ресурсы.*

Дар робита ба рушди васеъи соҳаи кишоварзии обёришаванда дар нимаи дуюми асри бист. Ҳама захираҳои оби мавҷуда дар ҳавзаи баҳрии баҳри Арал қариб пурра бароварда мешуданд. Ин ба марги баҳри Арал, таназзули заминҳо ва шартанонаи манфиатдор байни кишварҳои минтақа оварда расонид. Ин ихтилофот аз ҷониби рушди гидроэнергетикӣ, ки захираҳои обро истифода мебарад. Бо вуҷуди ҳамаи кӯшишҳои дар тӯли 30 соли охир ҳам кишварҳои ҳавзаи ниҳоӣ ва созмонҳои байналмилалӣ ҳанӯз натавонистанд ба ҳама гуна ихтилофот ноил нашаванд. Дар мақола вазъи кунунии бахши обтаъминкунии ҳавзаи баҳри Арал муҳокима карда мешавад, мушкилоти мавҷуда барои ҳалли онҳо ҳал карда мешавад.

Калидвожаҳо: *шартҳои манфиат, демография, энергетика, офатҳои муҳити зист, обёрӣ, рушди аҳолӣ, захираҳои об.*

Introduction

The Aral Sea basin consists of two river basins - the Amu Darya River and the Syrdarya River, which are located on the territory of five countries: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan. Water resources in the region are used mainly in two sectors of the economy - irrigation and hydropower.

Today, the problem of water use in the region is mainly associated with the death of the Aral Sea itself. His disappearance is recognized as a global catastrophe, the cause of which is the short-sighted command and administrative management of the economy in the former USSR. But the death of the Aral Sea is only part of the problem. In addition,

serious contradictions have arisen between the countries of the region in the sharing of transboundary water resources. And according to forecasts, these contradictions in the next 20-30 years will only worsen [1]. As a result, the situation in the water and energy sector in the Aral Sea basin today is usually unequivocally assessed as negative.

In fact, the situation is not so simple and unambiguous. From a purely economic point of view, the countries of the Aral Sea basin have achieved impressive successes in the development of their water and energy resources in the second half of the 20th century.

If at the beginning of the 20th century only about 3.5 million hectares were irrigated in the region, by the nineties the total area of irrigated land increased to 7.9 million hectares, including:

- in Uzbekistan - up to 4.3 million hectares
- in Kazakhstan - up to 0.8 million hectares.
- in Kyrgyzstan - up to 0.4 million hectares
- in Tajikistan - up to 0.7 million hectares.
- in Turkmenistan - up to 1.7 million hectares.

Especially intensive development of irrigation in the region began during the period of the USSR (mainly from the 60s to the 90s). What happened during this period can be called a unique experiment in the world practice of interfering with nature, its conquest.

At the same time, the entire increase in irrigated areas was provided by desert and semi-desert areas, such as the Karshi and Golodnaya steppes, etc. The total increase in irrigated land by the 90s of the last century was 4.4 million hectares (7.7 - 3.5), which is 1.37 times more than the area of the reduction of the Aral Sea (Table 1) - 32.1 thousand km^2 (58.9 - 36.8).

This, in fact, realized the idea of using the water resources of the Aral Sea, which arose long before the formation of the USSR. At the end of the 19th century, the famous Russian geographer Alexander Ivanovich Voeikov, traveling through Central Asia, suggested using the water resources of the Amudarya and Syrdarya rivers not to maintain the Aral Sea, which evaporates them, but to irrigate the desert and arid lands of the region.

In addition, when deciding on large-scale work on irrigation of desert lands in the region, in order not only to reduce, but completely eliminate their negative impact on the sea, it was decided to transfer part of the Siberian waters to the region. Again, this proposal was not an invention of the USSR. It was proposed in 1871

Table 1

Dynamics of the Aral Sea

Year	Level water, m	Volume, km³	Square surfaces km²	Mineralization, ‰	Runoff, km³/year
1960	53,40	1083,0	68 900	9,90	63,00
1980	46,40		51 675	18,00	
1982	44,40			19,00	
1984			59 878		
1989	40,40			24,00	
1990	38,24	323,0	36 800	29,00	12,50

Source: Aral Sea.www.ntsomz.ru.

in Kiev by Y. Demchenko, in his book entitled "On the flooding of the Aral-Caspian lowland to improve the climate of the neighboring countries".

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In the USSR, an attempt was made at the scientific and feasibility study of this project. On May 24, 1970, the Resolution of the Central Committee of the CPSU and the Council of Ministers of the USSR No. 612 was adopted "On the prospects for land reclamation, regulation and redistribution of river runoff in 1971-1985." The project envisaged the supply of 25 cubic kilometers of water per year by 1985.

More than 160 organizations of the USSR, including 48 design and survey and 112 research institutes (including 32 institutes of the USSR Academy of Sciences), 32 union ministries and 9 ministries of the Union republics, worked on the project for about 20 years. The preliminary cost of the project was estimated at 32.8 billion rubles, including: on the territory of the RSFSR - 8.3 billion, Kazakhstan - 11.2 billion and Central Asia - 13.3 billion. The benefit from the project was estimated at 7.6 billion rubles net income annually.

The same sharp increase in the Soviet period was observed in the energy sector. It can be said that as a matter of fact, starting from the 30s of our century, a completely new for it was created in the region, the modern basic industry - electric power industry. The total installed capacity of all power plants in the region reached 37.8 million kW by the mid-1990s, including:

- in Uzbekistan - 11.3 million kW.
- in Kazakhstan - 18.5 million kW.
- in Kyrgyzstan - 3.8 million kW.
- in Tajikistan - 4.4 million kW.

At the same time, hydropower industry in the upstream countries — Tajikistan and Kyrgyzstan — was about 90%, and in the rest of the countries of the region, about 20%. And that was just the beginning. The same growth rates of electric power industry in the region were foreseen in the future - "The Concept of the USSR Energy Development for the Period 1991 - 2005" provided for the construction and commissioning of hydroelectric power stations in Central Asia with a total additional capacity of 9.96 million kW.

Unfortunately, all these impressive results have led to the same great negative consequences. The intensity of the ecological imbalance processes in the region has sharply increased, which was particularly pronounced in the Aral Sea zone, land salinization and desertification increased, water quality has deteriorated in almost all sources.

As a result, already by the 70s, the water resources of the Syrdarya river basin turned out to be almost completely exhausted. In the Amudarya basin, there is also a shortage of water resources. Practically all this has turned into a global environmental problem of the region, and with respect to the Aral Sea - into an environmental catastrophe (Table 2).

Table 2

Main indicators of water and land resources use in the Aral Sea basin

Indicator	unit	**1960**	**1970**	**1980**	**1990**	**2000**
Population	million people	14.1	20.0	268	33.6	41.5
Irrigated land	thousand hectares	4510	5150	6920	7600	7990
Irrigated area per capita	ha per person	0.32	0.27	0.26	0.23	0.19
Total water withdrawal	km^3 per year	60.61	94.56	120.69	116.27	105.0
Including irrigation	km^3 per year	56.15	86.84	10679	106.4	94.66
Specific water intake per hectare of irrigation	m3 per ha	12450	16860	15430	14000	11850
water withdrawal per capita	m3 per person in year	4270	4730	4500	3460	2530

Source: SIC ICWC, 2000

Discussion

The simplest and most understandable explanation of the current situation would be if it were the result of any obvious errors. Unfortunately, this is not so. During the existence of the USSR, water basin utilization schemes were developed and refined many times, involving dozens of design and research institutes, on a scientific basis. Their examination was carried out at all levels, both in the central departments and in all the republics. The quality of these works can be assessed by the fact that their base - water balances are still used, with almost no serious changes. The problem of the Aral Sea itself was not missed in the problems of using of water resources in the region. It was clear to the developers that its volume would be drastically reduced. But it was decided to economically justify the sacrifice of shipping, fish and other related economic sectors in favor of cotton growing. The issue of salt during the drying of the Aral Sea was also considered; it was assumed that it will depart with water.

These problems did not arise from the fact that they have not been given enough attention. Simply, they were very complex, associated with too deep and abrupt changes in all sectors of socio-economic life and ecology. And too great was the belief in the possibility and power of man in the "struggle with nature". In the history of mankind there are few such examples.

It must be admitted that such extensive development of irrigated agriculture in the Aral Sea basin in the second half of the last century was forced and to some extent unavoidable. The reason for this was the demographic situation - a sharp increase in population (tab. 3).

Table 3

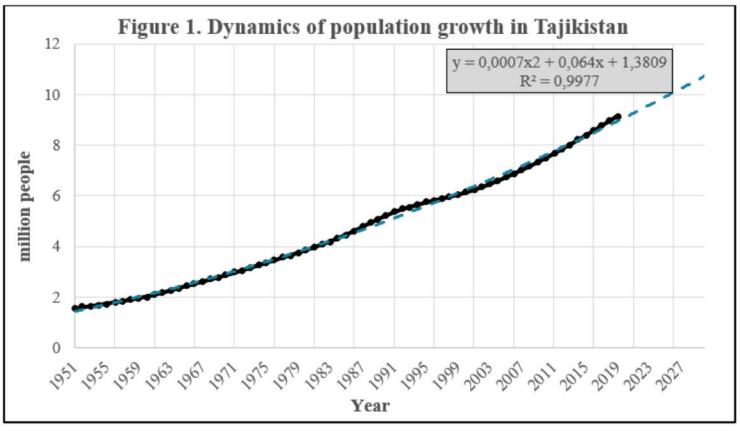
Population dynamics in the Aral Sea Basin, fact and forecast (million people)

Year	Kazakhstan	Kazakhstan	Tajikistan	Turkmenistan	Uzbekistan	Total
1990	16,7	4,3	5,4	3,7	20,3	50,4
1995	16,0	4,6	5,9	4,6	22,9	54,0
2000	14,9	4,9	6,1	5,4	24,3	55,6
2010	15,7	7,6	7,3	8,6	30,1	69,3
2025	25,9	8,4	9,0	13,1	40,3	96,7

Source: Royal Haskoning, GEF Agency IFAS.

Water and Environment Management Project. Report: Basin water-salt balances and their importance for national and regional planning. 2002

A typical example for all countries of the region is Tajikistan (Fig. 1). From 1950 to 2019, its population grew almost 6 times, that is, every 10 years during this period, an additional population appeared on the territory of the republic, equal in number to those living in it in 1950.



And this population growth continues at the present time. There is a vicious circle - the population growth for the agrarian countries of the basin requires the development of new lands, which in turn contribute to and even provoke further population growth. Moreover, as the data in Table 2 show, the growth of irrigated land in the region does not compensate for population growth — from 1960 to 2000, the irrigated area of land per capita decreased by almost a factor of two.

All this led to very serious negative environmental consequences. By 1980, almost all of the basin's water resources were fully utilized (Table 4).

The total water consumption in 1960 in the Aral Sea basin was 60610 million m^3, and by 1990 it had increased to 116271 million m^3, or 1.8 times. At the same time, the actual water consumption in the countries of Central Asia is rather close to the biological norm.

Table 4

Water use dynamics in the Aral Sea basin (million m3)

State	1960		1970		1980		1990		1995		1999	
	Total	Irrigation	Total	Irrigation	Total	Irrigation	Total	Irrigation	Total	Irrigation	Total	Irrigation
Kazakhstan	9750	9495	12850	12275	14200	12830	11320	10136	11300	10100	8235	7959
Kyrgyzstan	2210	2117	2980	2850	4080	3895	5155	4910	4966	4730	3291	3100
Tajikistan	9800	8690	10440	11170	10750	11820	9259	10239	12089	10400	12521	10150
Turkmenistan	8070	7950	17270	17092	23000	22735	23338	22963	23230	22470	18075	16788
Uzbekistan	30780	27900	48060	43450	64910	55510	63611	58156	54220	49020	62833	56660
The entire basin of the Aral Sea	60610	56152	94560	86837	120690	106790	116271	106404	105805	96720	104955	94657
including Amu Darya	30970	28550	53220	49282	66950	60345	69247	65151	64392	60700	66079	59568
including Syrdarya	29640	27602	41340	37555	53740	46445	47024	41253	41413	36020	38876	35089

Source: SIC ICWC

In addition, the situation is aggravated by the constantly progressive salinization and degradation of land, primarily irrigated (table 5). The area of irrigated land in the Aral Sea basin, where salinization of the top meter layer of soil is classified as moderate or strong, has increased significantly and by the year 2000 made up more than 30% of all irrigated lands of the basin.

Land degradation is one of the main reasons for the negative impact on agricultural production, especially on crop decline and instability.

Table 5

Salinization of irrigated lands in the Aral Sea basin (thousand hectares)

Region	Irrigated area in 1990	Saline land area							
		1990				1999			
		Weak	Moderate	Strong	Total	Weak	Moderate	Strong	Total
Basin of the Syrdarya River									
Kyrgyzstan	410	13	5	4	22	12	5	4	21
Uzbekistan	1860	603	151	48	802	465	250	80	794
Tajikistan	250	47	11	5	62	44	11	5	60
Kazakhstan	780		55	64	119	128	128	87	342
Total Syrdarya basin	3,300	663	221	121	1,005	650	393	177	1,219
Basin of the Amudarya River									
Tajikistan	690	29	16	3	47	29	16	3	47
Uzbekistan	2400	900	403	103	1406	867	500	138	1,504
Turkmenistan		457	478	158	1093	478	969	197	1644
Total Amudarya basin	4,810	1,386	896	264	2,546	1,373	1,485	338	3,195

Source: Central Asian Scientific Research Institute of Irrigation

These processes have a particularly large development in the mountainous and economically weak countries of the region - Tajikistan and Kyrgyzstan. This is facilitated by their difficult natural conditions - a strong dissection of the relief, steep slopes, uneven distribution of precipitation over time and territory, poor soil resistance against erosion, thinning of trees, shrubs and grass vegetation.

Much of the agricultural land in these countries (in Tajikistan - 76%) is located at an altitude of 800 - 2500 meters above sea level, on an area with slopes of 10 - 20°. Due to the economic instability and lack of food, the population of mountain villages in large areas plowing lands with a steepness of more than 15°, deforestation and shrubs, while destroying grass vegetation. In addition, unregulated, excessive grazing of livestock is under way and no measures are taken to increase pasture productivity. Strengthening of erosion processes is also promoted by debris flow. They are most often observed after plowing in deforestation areas.

The analysis performed is not an excuse for the approach to the development of the water-energy complex of the Aral Sea region used in the second half of the last century. But it helps to explain why, recognizing the error of past decisions, the Central Asian countries are simply not correct the situation back to what it was before 1950.

It becomes clear that today, in order to use water and energy resources more efficiently, it is not the refusal of the past that is needed, but its analysis, the correction of mistakes and the development of a modernization strategy. Today, one of the main problems in this regard is the existence of conflicts in the sectors of the water and energy complex themselves, which could not but lead to serious problems.

Tensions in the irrigation has emerged in the Soviet Union between the two countries and was suppressed by administrative-command methods - planned water allocation of resources between the Central Asian Republics [2], with the corresponding allocation of funds for the development and maintenance of irrigated land.

After independence of the countries of the region in 1991, the situation in irrigated agriculture in the region did not worsen. The conflict on water sharing between countries was settled, or rather, frozen due to the lack of funds for the development of new lands and some reduction of the demographic burden due to labor migration. Table 6, for example, provides official data on the number of permanent labor migrants from Tajikistan. According to independent experts, in reality, their number is 2-3 times more.

Table 6

Labor migration from Tajikistan (people)

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
People	412123	609316	573953	646298	677414	736446	750391	744368	799698	670806	252596	517308	487575

Source: Agency of Statistics under the President of the Republic of Tajikistan

Such a number of people who have left for work in other countries, and usually the most able-bodied, not only reduces the burden on agriculture, but also brings substantial income - remittances of ore migrants to their homeland today constitute a significant share of the republican budget. Labor migration is becoming today an important economic resource of Tajikistan.

The same situation with labor migrants is emerging today in the other republics of the Aral Sea basin, with the exception of somewhat more industrialized Kazakhstan and closed Turkmenistan.

The fact that the internal conflict in the field of irrigation between the countries of the region is not resolved, and only temporarily frozen is explained by the fact that within the framework of development strategies operating in Central Asia today, especially with the continuing high population growth, it is impossible to overcome the current problems of irrigation by reducing irrigated land, withdrawing them from the economic turnover. Therefore, constant criticism of its recent past is basically populism. There is no other way to explain why today the countries of Central Asia, declaring the excessive extension of irrigated agriculture during Soviet times as the main cause of the existing water crisis in the region, do not even try to resolve it in the simplest way - by reducing irrigation areas. On the contrary, practically all of them, especially the downstream countries, in their national development strategies, plan to further expand irrigated areas (Table 7). True, the countries of the region are also showing some caution today in the issue of the development of new irrigated lands, since the environmental negative consequences of past "successes" have not been completely forgotten.

In contrast to the internal irrigation conflict, the conflict between irrigation and hydropower, which was also suppressed by command-administrative methods in the USSR, became much more acute after 1991 and became interstate [3].

Table 7

Past and forecasted data on irrigated land (thousand hectares)

Year	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan	Total
1990	782	410	706	1329	4222	7449
1995	786	416	719	1736	4298	7955
2000	786	415	719	1714	4259	8101
2010	806	434	1064	2240	4355	8899
2025	815	471	1188	2778	6441	11693

Source: Royal Haskoning, GEF Agency IFAS. The Aral Sea Basin Program.
Water and Environment Management Project. Report: Basin water-salt balances and their importance for national and regional planning. 2002

The conflict of interest between hydropower and irrigation has one feature. Hydropower, located in the upper reaches of rivers, does not reduce the amount of water runoff for irrigation of the downstream countries. HPS to generate electricity simply passes water through the turbines. But hydropower can change the regime of water runoff in their own interests - for a uniform production of electricity over time. Such an energy regime does not meet the interests of irrigation. Hence it is clear that the simplest and most natural way to resolve the conflict between irrigation and hydropower can be the construction of own reservoirs in the territory of the downstream countries themselves. This would allow downstream countries to completely abandon runoff control services from upstream countries and become independent of them.

And such options are already being implemented today. Kazakhstan has already built the Koksaray reservoir in the Syrdarya river basin. Turkmenistan is implementing the project "Golden Lake" - the largest reservoir in the Amu Darya river basin, with a volume of more than one hundred cubic kilometers. Similar projects for the construction of reservoirs, although a small volume are available in Uzbekistan.

But the construction of such counter regulating reservoirs requires large financial expenditures; therefore, the economic efficiency of such projects is significantly lower than the regulation of water runoff by large reservoirs already existing in the upper reaches of the rivers (Nurek, Toktogul, Kayrakkum) [4] and, moreover, built mainly for irrigation purposes[1].

Another disadvantage of the construction projects of counter-regulating reservoirs for re-regulation of the runoff in the interests of irrigation in downstream countries is that they have to be built in lowland areas. They flood large areas of useful land and have shallow depths, which turns them into a kind of evaporator. For example, in the Koksaray reservoir, with an average depth of 6.5 meters, about 20% of its useful volume evaporates annually.

Another simple option for resolving the conflict, which is sometimes offered by upstream countries, is a proposal to return to

[1] Hydropower, in principle, does not require large reservoirs for its normal functioning. For example, in Norway, more than 800 hydroelectric power stations were built for energy purposes only, and none of them has such large reservoirs as Nurek and Toktogul.

the scheme of interaction between energy and irrigation that existed during Soviet times. The authors of the proposal believe that at that time Kyrgyzstan and Tajikistan supplied free water to downstream countries, while the latter provided them with free energy - gas, oil and electricity.

In fact, all energy resources were also paid during the USSR, although at non-market prices. That is, during the USSR, upstream countries, regulating the runoff for irrigation of downstream countries, bought their energy resources in return. At the same time, the downstream countries to some extent also paid for the water they received - by buying the electricity generated by this water. But not all, but only unnecessary, unclaimed for the countries-producers themselves. The state (USSR) only provided the necessary conditions for this purchase and sale, and not necessarily in equivalent amounts.

Another proposal based on the same principles is the introduction of water charges between countries in the region. Proponents of the right to recognize water as a commodity and establish a market price for it are upstream countries, taking into account the sovereignty they proclaimed for all natural resources on their territory.

In order to be more convincing, they often refer to the 1992 Dublin Conference, where the principles of water use were put forward, proclaiming that water has an economic value and should be regarded as an economic good. At the same time, the status of the Dublin Conference and its principles is raised to the level of international law, although in fact it is just a joint statement of the participating countries.

But the most important thing is that in the Dublin principles of water use the concept of "value" is used, and not "price", and even more so there is no mention of water as a product. And from an economic point of view, "value" and "price" are different concepts. Something can be very useful, even vital, that is, to have value, but not to have a market price. This, for example, the air we breathe. The distinction between these concepts is well illustrated by the "paradox of the cost of water and diamonds" known to economists from the 19th century, the essence of which is that although the value and usefulness of water necessary for human life is much greater than the value of diamonds having a purely decorative function, the price of water is incomparably lower than the price diamonds.

River water in its natural state is not a commodity, but it can be made a commodity, for example, after cleaning and bottling, or when delivered by tankers, such as when it was bought by Israel in Turkey in 1995. In the latter case, the price of water just transferred the cost of its preparation and delivery. A similar situation may occur when water is supplied from one country to another via canals.

The proposal to introduce paid water consumption between countries in the Aral Sea Basin essentially provides for double payment for the use of water resources for the upstream countries - for electricity generated by this water (from consumers of their own countries) and as a resource for irrigation (from consumers countries downstream).

In addition, several other complex issues and problems immediately arise here. The simplest of them is the determination of the price of such water. Not to mention the difficulty of calculating the price itself, it will need to be coordinated with the buyer countries, which is quite difficult.

The second question is the volume of water supplies. Should all water be paid for, or that part of it that is intended directly for the Aral Sea itself should be free? And if the water for the Aral Sea is free, then what to do if, for example, Uzbekistan, as it sometimes happens, redistributes it to its needs? And who will control all this? The same applies to sanitary discharges.

The next question is the regime of water supply. Naturally, if water is a commodity, then it should be delivered to customers only at that time and in the volumes that are determined (ordered) by the buyer. Then it turns out that if Uzbekistan and Kazakhstan will not order

water in the winter, then it will be necessary to stop the operation of hydropower plants of the upper reaches. And if this is not done, then the water supplied without an order will have to be paid fines[2]. And since the cost of water will be calculated by the countries of runoff formation, the fines, naturally, by countries consuming water. And will it not be that the fines will exceed the cost of the supplied water itself?

There are also issues with the water supply scheme. For example, in the Syrdarya river basin, the buyers of water formed in Kyrgyzstan are mainly Uzbekistan and Kazakhstan. But all of it flows to them through Tajikistan, and to Kazakhstan through Uzbekistan, that is, in transit. If water is a commodity, then such transit must be paid. Or will Tajikistan first have to buy all Kyrgyz water, and then sell it to Uzbekistan, which in turn will sell part of it to Kazakhstan? And, finally, who and how will all this water, whose consumption is constantly changing along the way, be measured? To do this, today neither the republics nor the region have the necessary institutions, gauging stations with equipment and specialists. And it is necessary to measure the water - any product must be identified and certified in order for it to pass through customs and tax procedures[3].

And finally, even if all these issues could be solved in any way, Tajikistan and Kyrgyzstan would simply transfer the management of the regimes of all their hydropower plants to the downstream countries, especially during the winter period - the latter, paying for water, will naturally determine and the volume of its supplies.

All the above-mentioned difficulties are confirmed by modern practice. In 2001, Kyrgyzstan adopted the Law "On Interstate Use of Water Objects, Water Resources and Water Facilities", which provided for water charges from neighboring states. But, unfortunately, the adoption of this law only lowered the level of trust in Kyrgyzstan from its neighbors; the republic has never received any payment for water as a resource.

At the same time, it should be recognized that the introduction of paid water use would be the simplest solution to the problem of relations between the countries of the region in the area of sharing water and energy resources. As shown above, today it is impossible primarily because of the lack of necessary feasibility studies. Therefore, it is of particular interest to consider one of the tools for implementing such an approach, proposed in 1997 by the President of Kazakhstan N. A. Nazarbayev - the International Water and Energy Consortium.

At the first stage, such a consortium could be created as a commercial organization that would engage in the exchange (purchase and sale) of water for energy between the republics of the region. As an economic mechanism for such an exchange, one can adopt the scheme provided for in the Agreement between the Republic of Kazakhstan, the Kyrgyz Republic, the Republic of Tajikistan and the Republic of Uzbekistan on the use of the water and energy resources of the 1998 Syrdarya River, but putting it on a more solid basis.

In general, such a scheme could look like this. The consortium buys from the upstream countries (Kyrgyzstan and Tajikistan) the excess electricity for them generated by them in the summer, during the growing season, carried out for the downstream countries. The consortium makes this purchase of electricity at prices that provide upstream countries with the opportunity to purchase the same amount of electricity in the winter, during the most scarce period for them (and during the period when

[2] By the way, such a situation today sometimes develops in the Syrdarya basin, in the Shardara reservoir and in the Kzyl-Orda region. The large amounts of water released from the Toktogul reservoir in winter are not only not claimed by the lower countries - Uzbekistan and Kazakhstan, but also cause great damage to them in the form of flooding. Obviously, this damage should be compensated by the countries - "sellers of water."

[3] The fact that such procedures will eventually be necessary is shown by the example of the exchange of electricity between Tajikistan (in the south) and Uzbekistan (in the north), which has been preserved from the times of the USSR until 2010. It is really just an exchange, barter, it is not accompanied by bank financial transactions. But despite this, such a barter is considered as export-import and so is reflected in the state statistics. In this case, the customs and tax structures regularly have questions to the power industry. And this is despite the fact that meters are installed on the borders of the republics.

they accumulate water in their reservoirs for the growing season). That is, the purchase of summer electricity is carried out at winter prices. The consortium sells this electricity at summer prices, which can be significantly lower than winter prices. The consortium will cover this price difference with irrigation water supplies, which, strictly speaking, is the main goal of the whole scheme. Such payment for water supply will be made in accordance with the legislation, which has already established a paid water supply in all countries of Central Asia and at the rates approved in them. Moreover, given the shortage of money in the republics, water can be paid to the consortium in real terms, in the form of agricultural products. The consortium will sell these products on the market, and as a result, all payments between upstream and downstream countries will continue to be made in cash.

In addition to simplicity, this scheme has other significant advantages. It moves away from the very difficult issue of introducing water charges between states, and at the same time uses the already established scheme of paid water supply in the countries themselves. The territorial boundaries of the consortium's activities also become insignificant. They can be extended to the entire Aral Sea basin. At the same time, the consortium does not replace the existing managerial and economic structures, but works in parallel and in close connection with them. But at the same time, he has the opportunity, both to cooperate and to compete with them. And, finally, its further development in any form is possible.

A proposal is also being put forward (from the upstream countries) that it is not the water itself that should be paid for, as a commodity or resource, but the operating costs of the waterworks that regulate the river runoff. In this case, the cost of water is determined by the costs transferred to it. Although this removes the problems associated with water as a commodity, other, equally complex, immediately appear.

First of all, the distribution of total operating costs for all participants means their joint operation and, accordingly, joint ownership. But then, in the same proportion, the total profit from the production of electricity, which is much higher than the costs, should be divided.

Further, for all existing integrated hydropower plants, if not impossible, it is practically very difficult to isolate from the general complex of structures the elements ensuring the supply of water and determine their cost and operating costs. For example, how to determine what provides the water-conducting turbine path of a hydropower plant — the generation of electricity or the supply of water? Or what provide emergency spillways - the supply of water or protection from the overflow of water through the dam? Even more difficult is the issue with the river bed itself and the coastal fortifications on it. And finally, even having solved all these issues, it is unclear what the general scheme of payment of compensatory operating costs should be for individual participants: the lowermost hydroelectric system does not supply water to anyone and, therefore, it is not entitled to any compensation, but it receives water passing through all the overlying waterworks and therefore he must compensate the latter for all operational costs. Of course, this is absurd, but any other such schemes are also no better.

And finally, in any case, any such approach requires coordination with neighboring countries.

It is also proposed, when resolving the conflict of irrigation-hydropower, to proceed not from the national, but from the general, regional interests of the participating countries and on the basis of this to develop a general optimal scheme for regulating and using river runoff.

Here it can be emphasized that statements about the regional interests of the countries of Central Asia and even their priority over national ones, does not have any real grounds. Unlike national interests, which have their specific expression in official programs, strategies, plans, and other government and departmental documents, regional interests are abstract. At

best, regional interest can only be defined on the basis of national, as their mutually beneficial coordination - on the basis of interstate treaties, agreements, contracts.

The principle of optimizing the overall benefits involves the selection of such options for regulating the runoff and, accordingly, such regimes of operation of hydropower and irrigation in which the maximum total profit from their activities is achieved. Of course, in this case, with today's independence of all the participating countries, it is unacceptable such a solution, in which the maximization of total profits will be achieved due to the fact that one party will have losses, but the other will receive a profit that exceeds them. Therefore, in this variant, it is not the unconditional optimization that is usually considered, but the Pareto optimization, in which all decisions are made in a space where a single participant cannot worsen the situation. With all the attractiveness of this approach, a problem arises with the choice of the start of optimization. Taking the regime required for hydropower as the beginning of the optimization process, changes will be possible only from the side of irrigation, and vice versa.

But it's not only that. The solution of the optimization problem of maximizing the overall benefits in the case of hydropower and irrigation, in fact, does not require any mathematical model calculations. It is uniquely determined in favor of irrigation. This is explained by the fact that in any regime the total electricity generation at hydroelectric power plants depends only on the amount of water through the turbines, which is the same for all regimes. Therefore, the profit of hydropower does not depend on the regime of runoff regulation. As a result, the general optimization depends only on irrigation - the optimum regime for it will automatically be optimal for the general hydropower and irrigation system. By the way, this approach was used during the USSR. Today, there is a perception that irrigation at that time was the main priority of the economy. In fact, the priority was not irrigation itself, but regulation of the runoff in its interests, since in this case the associated generation of hydropower was independent of the runoff regulation regime. Another thing is that in reality, for energy, not only the overall output is important, but also its distribution by seasons, but such a task under the USSR was no longer solved within the framework of interrelationships within hydropower and irrigation, but within the framework of the common United Energy System of Central Asia.

But in any case, it should be recognized that the development and justification of optimal schemes for the sharing of water resources can be very useful to all countries of the region. It can serve as a base, the best option that countries should strive for when they cooperate with each other on the basis of mutual compromises.

Thus, all the approaches discussed above, based on the direct opposition of existing hydropower and irrigation, do not allow today to find a solution to the problem of their interaction, which would satisfy both parties.

At the same time, effective solutions to the problem of the relationship between hydropower and irrigation, taking fully into account their mutual interests, are possible by expanding the scope of the problem, by partially going beyond the boundaries of these industries.

The basis of this method is the principle of relations between countries of transboundary basins, in which the countries of the runoff formation zone (and owners of hydroelectric facilities) provide runoff control services to downstream countries that use water for irrigation. These services in this case represent a transition from the national energy regime of operation of the reservoirs of upstream countries to the irrigation regime in which downstream countries are interested. For this, the latter compensate the upstream countries for all the costs and losses associated with this [5].

This approach is adopted in the "Agreement between the Government of the Republic of Kazakhstan, the Government of the Kyrgyz Republic, the Government of the Republic of Tajikistan and the Government of the Republic of Uzbekistan on the use of water and en-

ergy resources of the Syrdarya river basin" (Bishkek. March 17, 1998), article 4 of which provides that upstream countries provide the necessary supplies of water for irrigation of downstream countries. At the same time, the additionally produced electrical energy associated with these water supplies, in excess of the needs of Kyrgyzstan, Tajikistan, is transferred to Kazakhstan and Uzbekistan. Its compensation is provided by supplies to Kyrgyzstan and Tajikistan in the equivalent volume of energy resources (coal, gas, fuel oil, electricity), as well as other products (works, services) or in monetary terms.

Based on this agreement, the further presentation of the proposed methodology will be made, focusing on the Syrdarya river basin. Of course, there are no restrictions for its application to any other transboundary basins.

For the Syrdarya river basin, the runoff formation zone of which includes the Toktogul (Kyrgyzstan), Andijan (Uzbekistan) and Kairakkum (Tajikistan) hydropower plants with regulating reservoirs, the method is implemented as follows. First, for all three of the above hydroelectric complexes, the modes of operation are determined in accordance with national interests. Calculations of these regimes are carried out sequentially, first for the uppermost Toktogul, then the middle Andijan and, finally, the lowest Kairakkum hydro system. As for the Toktogul and Andijan hydropower plants, the national regimes are calculated both for the operation of hydro-systems "in the open field", based only on the natural regime of the Naryn and Kara Darya rivers. In contrast, the national optimal regime of the Kairakkum hydroelectric complex is no longer calculated on the basis of the natural runoff of water in the river, but on the basis of those releases that were calculated above for the Toktogul and Andijan hydroelectric complexes.

As a result of the last calculation, it is possible to determine the regime of releases from the Kairakkum reservoir, including the volumes of water that can be used by downstream countries during the vegetation period. As experience shows, these volumes and the schedule of water supply to the vegetation, calculated only on the basis of the national interests of the countries of runoff formation, will not meet the interests of the downstream countries. To ensure the latter, it is necessary to regulate the runoff, change the operating mode of the waterworks.

Such re-regulation of runoff should start from the lowest Kairakkum hydropower plant. The two downstream hydropower stations - Andijan and Toktogul should be included in the work sequentially, as necessary.

Among other things, this scheme provides the most minimal cost of services for regulating the runoff, since the latter significantly increases for the upper reservoirs in relation to the lower ones. A comparative analysis of the "prices" for water for the Syrdarya river basin proves that the most effective separation of functions between reservoirs when regulating the runoff should be based on the principle of bottom-up [6]. That is, first all the possibilities of the cheapest Kairakkum reservoir are used, then Andijan and, finally, the most expensive - Toktogul. And Toktogul comes into operation only if the resources of the first two possibilities are insufficient. This significantly reduces the total cost of services.

From the above it is clear that in the proposed methodology, the services for regulating the water runoff, which the upstream countries provide to the downstream countries, is changing its national regimes of the reservoirs. What kind of losses do the countries of the runoff formation zone bear and what should the downstream countries compensate for them?

As is known, the upstream countries - Tajikistan and Kyrgyzstan, are interested in the energy regime of their hydropower plants. Therefore, losses of these countries can only be losses of electricity associated with such a change in the modes of operation of their hydropower plants: from energy to irrigation. But, as noted above, the generation of electricity at hydropower plants depends primarily on the volume of water used, which is the same under any con-

ditions. The pressure of the hydroelectric station can also be considered the same for both the energy and irrigation regimes, since both there and there the reservoirs are equally filled and emptied only at different times of the year. Thus, at first glance, when providing services for water runoff regulation, upstream countries, as it were, do not incur any losses. But in reality, this is not the case, since in fact, upstream countries are interested not only in generating total electricity, but also in maximizing it in the winter, the most scarce and coldest period, simultaneously coinciding with lower discharge in rivers. Therefore, the upstream countries as a result of the transition from the energy regime to the irrigation one, in reality, have losses - losses of winter electricity. But at the same time they produce an equivalent excess of it in the summer, growing season. Again, it turns out that if these countries had the opportunity to exchange this surplus summer electricity for scarce winter electricity over time, they would also have no losses. The problem is that today the upstream countries cannot carry out such an equivalent exchange with their own forces. There are several reasons for this. This is a certain shortage of winter electricity in the downstream countries themselves, and problems with the transit of electricity, and difficulties in exporting electricity to foreign countries, etc.

From this it becomes clear that the countries consuming water should compensate for the countries that regulate the water runoff. They should help the upstream countries to perform the above exchange, which they themselves cannot make.

It can be noted that with the proposed scheme for regulating the water runoff of the Syrdarya river with three hydro-systems in the interests of both irrigation and hydropower, none of the participants have any losses. Uzbekistan and Kazakhstan receive in full and in the required mode irrigation water, Kyrgyzstan and Tajikistan - the energy they need, also under optimal conditions for the republics. It is only necessary that the thermal power plants of Uzbekistan and Kazakhstan operate in a somewhat modified mode. But since the latter is determined not by the regime of water runoff, like that of a hydroelectric station, but is set rather arbitrarily, they also do not have any losses.

Thus, the most effective way to resolve the conflict between irrigation and hydropower is provided by compensation in the form of electricity exchange between the countries of the region. But this requires a properly functioning united energy system, which in Central Asia has recently been partially destroyed. Therefore, today the question of its restoration and further development in today's market conditions becomes very important [7].

It should be noted that the integrated energy system is needed not only for the implementation of compensation in the framework of the relationship between irrigation and hydropower. She in itself has many positive moments.

Conclusion

Modern problems and challenges of the joint integrated use of water and energy resources of transboundary rivers of the Aral Sea Basin in Central Asia have a complex historical, political, socio-ecological and economic nature, and, as shown by 30 years of experience, cannot be solved by simple financial and economic methods even with the help of developed countries.

For this, the countries of the region need not only new effective approaches and technologies, but also a complete change of paradigm oriented today towards accelerated development. The latter should be replaced by a sustainable development paradigm with limited resources, including human resources.

In addition, engineering and feasibility studies of national and regional strategies for the development and operation of the water and energy sector and the signing of relevant interstate agreements are necessary.

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ПАСТБИЩНОЕ РЫБОВОДСТВО В ТАДЖИКИСТАНЕ С УЧЕТОМ РЕФОРМЫ ВОДНОГО СЕКТОРА

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В статье обоснованы значения пастбищного рыбоводства в водоемах республики. Применение прогрессивных методов и технологий выращивания экологически чистой рыбы, за счёт использования естественной кормовой базы растительного и животного происхождения. Предлагается приспосабливать аквакультуру с учетом создания в республике бассейнового управления водными ресурсами.

Ключевые слова: *пастбищное рыбоводство, озера, сазан, белый амур, белый толстолобик, сом, судак, речные бассейны, подбассейны.*

In the article the values of the fish-farming are presented in the reservoirs of republic. Application of progressive methods and technologies of growing ecologically of clean fish, due to the use of natural feed base of vegetable and animal origin. It is suggested to adjust aquiculture taking into account creation in the Republic the water resources basin management.

Keywords: *fish-farming, lakes, white cupid, sheat-fish, pike perch, river basins, subbasins.*