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HUMAN ACTIVITIES IN THE SYRDARYA RIVER BASIN

Changes in land use and water use can greatly impact the cycling of water and water-borne substances. Increased redistribution of river water to irrigated fields can cause enhanced evapotranspiration and decreased river discharge. Additionally, the water quality can be affected by the external input of fertilisers and pesticides, and by changed pollutant transport pathways in expansive irrigation canal systems. This work examines basin-scale changes in water use, land cover/use change (LLUC), water quality under conditions of intensified irrigated agriculture, development water constructions. When considering land use in the basin, it can be noted that most of the land is grassland (about 42%) and cropland (about 28%). A comparative analysis of 1992 and 2015 revealed that bare land and forestland area decreases. The percentage of the urban area during the increased to 1.0% during the study periods. The urban area expanded most rapidly mainly by encroaching into the agricultural area and grassland. Moreover, it revealed that over the long-term period the water construction was intensively taking placed in the basin. Especially since the 1960s. The construction of reservoirs and the increase in water withdrawal from rivers significantly changed their water regime, especially in the downstream. In fact, due to agricultural, industrial, and urban development's, such as irrigation and drainage, hydraulic structure across a river, the elements of the hydrological cycle have changed in terms of quantity and quality, both in time and space. In this work, an attempt is made to analyze the effect of human activity on river runoff.

Key words: human activities, land cover/use, irrigation, water withdraw, water construction.

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Сырдария өзені алабындағы адам әрекеті

Жерді пайдалану мен суды пайдаланудың өзгеруі су айналымына және суда тасымалданатын заттарға қатты әсер етуі мүмкін. Өзен суын суармалы егістікке қайта бөлудің артуы буланудың жоғарылауына және өзен ағынының азаюына әкелуі ықтимал. Сонымен қатар, сырттан тыңайтқыштар мен пестицидтердің енуі, сондай-ақ кең суармалы каналдар жүйесіндегі ластаушы заттардың тасымалдану жолдарының өзгеруі судың сапасына әсер етуі мүмкін. Бұл жұмыста өзен алабы масштабында суды пайдалану, жер жамылғысы мен жерді пайдалану, интенсивті суармалы егіншілік жағдайындағы су сапасы және су құрылымдарының дамуы өзгерістері зерттелінеді. Өзен алабындағы жерді пайдалануды қарастырған кезде, жердің көп бөлігі жайылым (шамамен 42%) және егіншілік жерлер (шамамен 28%) екенін атап өтуге болады. 1992 және 2015 жылдардағы салыстырмалы талдау көрсеткендей, пайдаланылмайтын және орманды жерлер ауданы азайып келеді. Зерттеу кезеңінде қалалық жердің үлесі 1,0% дейін өсті. Әсіресе, елді-мекен аймақтары тез өсіп келеді, негізінен ауылшаруашылық жерлері мен жайылымдар есебінен. Сонымен қатар, ұзақ уақыт бойы су құрылыстары өзен алабында қарқынды түрде жүргізілген болатын. 1960 жылдан бастап су қоймаларының салынуы және өзен суын алудың көбеюі олардың су режимін айтарлықтай өзгертті, әсіресе өзеннің төменгі ағысында. Шындығында, суару және дренаж, гидротехникалық құрылыстар сияқты ауылшаруашылық және өндірістік кешеннің дамуына, сондай-ақ елді-мекендердің ұлғаюына байланысты гидрологиялық цикл элементтері уақыт бойынша да, кеңістікте де саны мен сапасы жағынан өзгерді. Бұл жұмыс адам іс-әрекетінің өзен ағынына әсерін талдауға тырысады.

Түйін сөздер: адамның іс-әрекеті, жер жамылғысы, жер суағару, су алу, су құрылысы.

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Человеческая деятельность в бассейне реки Сырдарья

Изменения в землепользовании и водопользовании могут сильно повлиять на круговорот воды и переносимых водой веществ. Повышенное перераспределение речной воды на орошаемые поля может вызвать усиление испарения и уменьшение речного стока. Кроме того, на качество воды может повлиять поступление удобрений и пестицидов извне, а также изменение путей переноса загрязнителей в обширных системах оросительных каналов. В данной работе исследуются изменения в водопользовании в масштабе бассейна, изменение покрова земли и их использования, качество воды в условиях интенсивного орошаемого земледелия, развитие водных сооружений. При рассмотрении землепользования в бассейне можно отметить, что большая часть земель - это пастбища (около 42%) и пахотные земли (около 28%). Сравнительный анализ 1992 и 2015 годов показал, что площадь неиспользуемых земель и лесных массивов уменьшается. Доля городской территории в период исследования увеличилась до 1,0% в период исследования. Особенно застроенные регионы росли быстрее всего, в основном за счет сельскохозяйственных земель и пастбищ. Более того, выяснилось, что в течение длительного периода водные сооружения интенсивно размещались в речном бассейне. Начиная с 1960-х гг. строительство водохранилищ и увеличение забора воды из рек существенно изменили их водный режим, особенно в нижнем течении. Фактически, из-за развития сельскохозяйственного, промышленного комплекса, такого как ирригация и осушение, гидравлические сооружения, а также увеличения населенных пунктов, элементы гидрологического цикла изменились с точки зрения количества и качества как во времени, так и в пространстве. В этой главе делается попытка проанализировать влияние человеческой деятельности на речной сток.

Ключевые слова: человеческая деятельность, земельный покров, орошение, водозабор, водное строительство.

Introduction

Human activity has the potential to indirectly and directly affect water quantity and the natural flow regime of a river system. Indirect impacts to the hydrologic cycle can result from land cover/use changes. Direct impacts can result from water diversions, withdrawals and discharges, and from dams (flow regulation and water storage). In each river basin, if not all, then most of the factors mentioned can act. At the same time, in a specific basin, some factors are the main, while others are secondary.

Since the middle of the 21st century, dramatic changes in flow influenced by human activities (e.g., water diversion and land use/cover change) have been detected in many basins (Marengo, Tomasella, and Uvo 1998; Milly et al. 2008; Ma et al., 2010). Human activity, such as land cover/use change, urbanization, and water conservation projects have significant impacts on river water, altering the regional hydrologic cycle by changing runoff-generation conditions (Deng and Chen 2017). The existing extent of human-generated change to land cover has increased global runoff by 7.6% and reduced global annual average terrestrial evapotranspiration by 5%, which is approximately equivalent in volume to annual global surface water withdrawals (3200km^3/year) (Sterling, Ducharne, and Polcher 2013; Piao et al, 2007) indicated that land use change increased global runoff by 0.08 mm/year, which accounted for approximately 50 % of the reconstructed global runoff trend over the last century (Zhang et al. 2015).However, different human activities may have different roles in runoff change. Experimental studies indicate that the runoff modulus of grassland is 61.1%–75.8% of that of bare land; forest land has a lower runoff modulus as compared to that of bare land; while the runoff modulus in urban areas is much higher (Chen, Wang, and Xu, 2004). At the same time, industrial water consumptions and agricultural water consumptions have a direct impact on river flow, with agriculture accounting for over 70% of total water use (Zhang, 2005).

In arid and semi-arid zones (such as Central Asia), irrigation is the main anthropogenic factor. However, in these areas, there is drainage of waterlogged lands, regulation of runoff over time and territory, industrial and communal water consumption. Their role, in most cases, is secondary, although some of them in certain periods of time are of primary importance.

Assessment of human impact on water resources is most relevant for regions and river basins with developed irrigated agriculture, where water scarcity is already present. Several studies (Cai, McKinney, and Rosegrant, 2003; Petr, 2003) conducted to analyze the impact of irrigated agriculture and economic activity on the water balance and water resources of the main river watersheds in the arid zone showed that irrigation leads to a radical change in the ratio of the components of heat, water and salt balances both within the irrigated massifs and on adjacent lands and water bodies (lakes, rivers, reservoirs). Depending on the extent of irrigation, climatic and physical-geographical features of the territory, the trend of runoff reduction can be significantly different.

At present, a catastrophic water-ecological situation has developed in the Syr Darya river basin, which is explained, first of all, by its transboundary position, as well as by the confluence of the lower part of the basin to arid inland areas where the river almost does not accept tributaries (Dukhovny and Litvak, 1977). About half of the population of Central Asia is concentrated in the Syr Darya river basin. Agriculture in the river basin and the industry have obtained a high economic level, notably within Uzbekistan. Large reserves of thermal resources and the availability of fertile land, on the one hand, and a lack of precipitation, on the other hand, led to the widespread development of irrigation. Therefore, the water resources of the basin, especially river waters, which are mainly used for these purposes, undergo some quantitative and qualitative changes (Amirgaliev, 2007).

Since ancient times, the river basin has been used as irrigation land. But from 1950-1960 of the 20th century, irrigation lands grew 3-5 times. Which led to an increase in water intake from the river. Also, from the 1950s, water construction in the river basin began intensively. As we know, in the lower river, in the second half of the last century, the Syr Darya acutely felt a shortage of water, and about 30 years ago, runoff at its mouth was reduced to almost zero. But at the end of the 80s on the territory of the former USSR, people’s views on the state of the environment changed significantly, and the population of the Syr Darya became more careful about water resources. As a result, already in the early 1990s, Syr Darya Basin water began to flow regularly into the northern part of the Aral Sea. Although the volume of this water was about 2-4 times less than the amount of natural runoff (14.9 km^3), it was enough to flood a significant part of the modern “Small Aral” and there the desalination process began. Currently, the annual runoff at the mouth of the Syr Darya river ranges from 3.6 to 9.0 km^3(Sambaev 2017).

In the work we want to analyze human activity in the river basin by the dominant types of human activities: 1) to study the change of land cover/use; 2) consider the impact of irrigation on the water resources of the basin; 3) analyze the main and large water construction in the Syr Darya River basin.

Study area

The Syr Darya River, the second largest river in terms of flow volume in Central Asia (catchment area 219,000 km^2) is the result of the confluence of two big rivers: the Naryn (59,900 km^2) and Karadarya (30,100 km^2). Practically all flow of the Syrdarya forms in the mountains and foothills which border the cotton-growing regions: the Fergana valley, Chrchik-Ahangaran-Keles Irrigation Region, the Hungry Steppe, and the Dalverzyn steppe (Figure 1).

Downstream of Chardara Reservoir the river flow is spent for irrigation needs and evaporation losses from the flood plain. In the 800-km length up to Kazaly only one tributary flows into the Syrdarya – the Arys river (14,000 km^2).

River basin The Syr Darya consists of six main parts: the river basin. Naryn – the main tributary of the Syr Darya, collecting water in the Central Tien Shan; Karadarya – the second most important tributary of the Syr Darya; Ferghana Valley, to the center of which more than 100 rivers flow from the surrounding mountains, mostly not reaching the Syr Darya; Western Tien Shan, where the rivers Akhangaran, Chirchik, Keles, Arys come from, which are the right-bank tributaries of the Syr Darya after it leaves the Ferghana Valley; The southwestern slopes of the Karatau ridge, from which numerous small rivers flow down, not reaching the Syr Darya; flat part of the pool. The Syr Darya basin is divided into two, from the point of view of economic use, parts: the first is the upper, mountainous zone of runoff formation (the whole of Naryn and the upper Karadarya), where there is practically no fence for irrigation, and the second part is the valley (Syr Darya channel), where the main irrigated land and water withdrawal prevails over the lateral inflow. Irrigated lands are concentrated in the valley regions, primarily in Uzbekistan and Kazakhstan (Sorg et al., 2014).

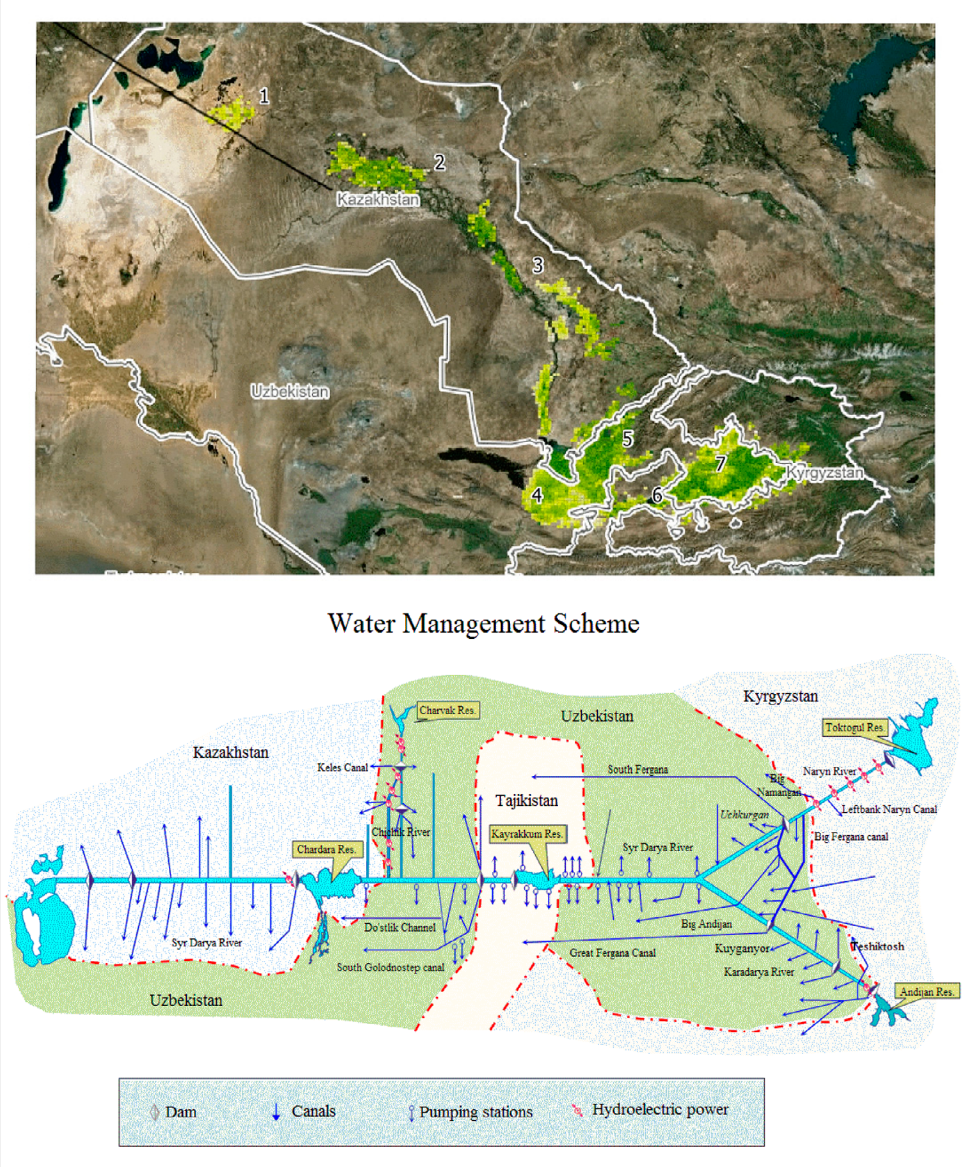

Figure 1 – Irrigation zones of the Syr Darya river basin (1 – Kazaly; 2 – Kyzylorda; 3 – Arys-Turkestan; 4 – Hungry Steppe; 5 – CHAKIR; 6 – Dalverzin and Fergana Irrigation Zones) and Water Management Scheme (Source: CAWa and BWO "Syrdarya")

Data and methods

For analysis land cover/use, we used several land cover products, including MODIS land cover products (MCD12Q1) (https://lpdaac.usgs.gov/dataset_discovery/modis/), the global surface coverage data (GlobeLand30) (http://www.globeland30.com) and the Climate Change Initiative Land Cover (CCI-LC) project (https://www.esa-landcover-cci.org). Statistical data about irrigation, water withdraw and return water was obtained from the Regional Information System on Water and Land Resources in the Aral Sea Basin (CAWater-IS) (http://www.cawater-info.net) and Regional Research Network "Water in Central Asia" (CAWa) (http://wuemoca.net/app/).

Results and discussion

Land cover/land use change in basin

One of the most important signs of human activity is land cover/use change (Figure 2). To determine the land cover/use change induced by human activity, we used the Raster Calculator tool for ArcGIS to analyze the conversion condition between the year 1992 and 2015 land cover/use type. Table 1 describes the conversion percentage of each land cover/use type from 1992 to 2015 in the whole basin. In table 1, the total rates in 1990 and 2015 represent the amounts of each land use type during the first period and the second period, respectively.

Both the bare land and the urban areas increased, whereas the remaining types (e.g., forest, and grassland) decreased. The percentage of urban area was 0.2 during the first period, and this percentage increased to 1.0 during the second period, indicating rapid urban expansion during the years.

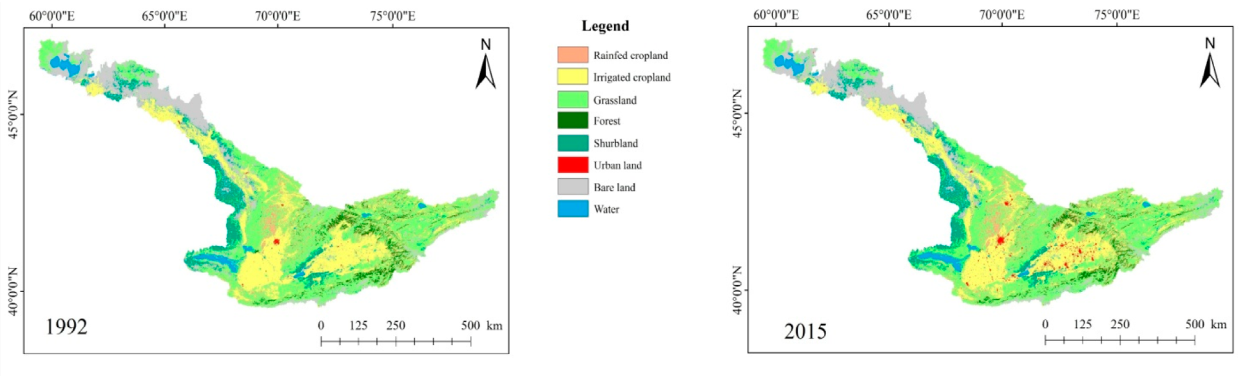

Figure 2 – LULC types in the Syr Darya River Basin in 1995 and 2015

Grassland is the predominant land cover/use type in the study area, respectively accounting for 41.9% and 42.6 % of the total land area of the river basin in 1992 and 2015, followed by bare land. However, bare land proportion is declining over time. The proportions of the cropland areas in the two periods are 27.7% and 28.1%, respectively, and they slightly increasing between these periods. Compared with the grassland area in 1992, that in 2015 increases by 2%. From 1992 to 2015, the land area for construction exhibits the highest interannual dynamic change. The forestland area decreases by 0.5%, and the water area increases by 0.2%. According to some studies, a significant increase in precipitation could have affected the increase in grassland and water area. Over the past 17 years, the area of water bodies and wetlands in five countries of Central Asia has increased significantly (especially the areas surrounding the Aral Sea and Lake Balkhash). In addition, with a decrease in the drought index, pasture areas in southern Central Asia and natural vegetation increased significantly (Hu and Hu, 2019).

Table 1 – The conversion percentage (%) of each land use type from 1992 to 2015

LULC type	R-land	G-land	I-land	F-land	S-land	U-land	B-land	Water	Rate % (2015)
R-land	4.56	0.42	0.00	0.20	0.00	0.00	0.01	0.00	5.2
G-land	0.37	40.26	0.13	0.33	0.00	0.00	1.52	0.01	42.6
I-land	0.01	0.72	21.86	0.15	0.00	0.00	0.18	0.00	22.9
F-land	0.08	0.13	0.01	2.88	0.00	0.00	0.01	0.00	3.1
S-land	0.00	0.00	0.00	0.00	7.29	0.00	0.00	0.00	7.3
U-land	0.08	0.18	0.60	0.00	0.00	0.17	0.01	0.00	1.0
B-land	0.02	0.17	0.02	0.01	0.00	0.00	14.88	0.02	15.1
Water	0.00	0.07	0.00	0.01	0.00	0.00	0.14	2.50	2.7
Rate % (1992)	5.1	41.9	22.6	3.6	7.3	0.2	16.7	2.5	

R-land-Rainfed Cropland; G-land-Grassland; I-land Irrigated-Cropland; F-land-Forest; Sh-land-Shurbland; U-land- Urban land; B-land-Bare land

Water construction in the basin

The Syr Darya River Basin, the main cotton base, belongs to ancient irrigation areas. In 1913, 1073 thousand ha were irrigated in the Syr Darya river basin (up to the Chardara); including 743 thousand hectares in the Ferghana Valley, 219 thousand hectares in the CHAKIR, 50 thousand in the Hungry Steppe and 7 thousand hectares in Dalverzin (Chembarisov, 1988; Micklin and Williams, 1996).

In the period 1933-1938, construction of large hydraulic structures on the Karadarya River (Kampyrravat Dam) and on the Chirchik River (Gazalkent Dam) began (Rubinova, 1979). This allowed us to switch to planned water use in the basins of these two largest rivers. At the same time, work was underway to increase the water availability of low-water systems by connecting them to high-water ones. However, a radical reorganization of the water economy of the Syr Darya river basin, which allowed significantly expanding the size of irrigated lands and increasing their water supply, began in 1938-1940, when the Northern, Southern and Big Ferghana canals were built (Table 2). In the same years, the construction of the Sarysui, Fayzyabad, Rishtanbogdad collectors was started. In 1950, one of the largest collectors in the Ferghana Valley – North Bogdad entered service. Also, widely irrigation and drainage construction took place in the Hungry and Dalverzinsky steppes.

The construction of the largest hydroelectric facility on the Naryn River and a number of pumping stations on the Syr Darya River made it possible to significantly increase the size of the lands irrigated from these sources. As a result of this, the areas that feed from the Karadarya River and the side tributaries of the Syr Darya River within the Fergana Valley have somewhat decreased, and their water supply has increased (Antipova et al., 2002).

Table 2 – Main Water construction in the Syr Darya basin

Year	Main Canals and Resrvoirs	River	Feature
1913	Do'stlik	SyrDarya	Capacity of headworks -230 m^3/sec
1922	Left Bank Karasu	Chirchik	Capacity of headworks -160 m^3/sec
1930	North Fergana Canal	Naryn	Capacity of headworks -110 m^3/sec
1930	Big Fergana Canal	Naryn and Karadarya	Capacity of headworks -200 m^3/sec
1946	KazalyCanal	SyrDarya	Capacity of headworks -100 m^3/sec
1947	DalverzinCanal	SyrDarya	Capacity of headworks - 75 m^3/sec
1951	South Golodnostep Canal	SyrDarya	Capacity of headworks - 300 m^3/sec
1959	Kairakum reservoir	SyrDarya	NominalVolume: 5200 mln.m3
1959	Kyzylorda Canal	SyrDarya	Capacity of headworks -226 m^3/sec
1963	Charvak reservoir	Chirchik	NominalVolume: 2006 mln m^3
1965	Chardara reservoir	SyrDarya	NominalVolume: 4000 mln m^3
1968	Kyzylkum	SyrDarya	Capacity of headworks -220 m^3/sec
1970	Big Andijan	Naryn	Capacity of headworks -200 m^3/sec
1974	Big Namagan	Naryn	Capacity of headworks - 61 m^3/sec
1978	Andijan reservoir	Karadarya	NominalVolume: 1900 mln m^3
1982	Toktogul reservoir	Naryn	NominalVolume: 19500 mln m^3
1992	Arnasay system	SyrDarya	NominalVolume: 1000 mln m^3
2009	Koksaray reservoir	SyrDarya	NominalVolume: 3000 mln m^3

The construction of the Kayrakkum, Chardara, Charvak and other reservoirs in 1950-1970 made it possible to further expand irrigated areas and increase their water availability. The Toktogul and

Andijan and a number of smaller reservoirs on the tributaries of the Syr Darya River serve the same purpose. The increase in irrigated areas within the irrigation zone of the river basin is illustrated in the table 3. According to these data, in the first half of the 1970s, the irrigated area in the upper part of the basin (Fergana and ChAKIR) increased by 1.6, relative to the beginning of the 1930s, in the middle course by 5.6 and in the lower by 3.3 times. The increase in water intake from rivers and the construction of reservoirs significantly changed their river regime, particularly in the lower reaches. In connection with the increase in the flow of collector-drainage (return) water into the rivers in the autumn months, water consumption in them is somewhat increased. In general, the hydrological conditions of the river basin deteriorated with the development of irrigation, especially in the downstream of the river (Chembarisov et al., 2013).

Table 3 – The size of irrigated areas in the irrigation zone of the Syr Darya river basin, thousand ha

Periods	Ferghana Valley	CHAKIR	Hungry Steppe	Dalverzin Steppe	Downstream
1925-1930	670	190	62,9	22	46
1931-1940	822	192	90.9	27	72
1941-1950	820	244	123	25.2	-
1951-1960	953	284	223	44.5	88
1961-1965	993	307	291	49.3	102
1966-1980	1102	346	486	50	199
1981-1990	1300	475	375	185	252
1991-2000	-	428	337	-	345
2001-2010	1600	450	351	-	365

Irrigation and irrigation and drainage construction in the Syrdarya river basin has turned it into a complex water management system that substantially transforms within its limits the river flow coming from the formation area.

Irrigation and Water withdraw in the basin

The increase in the size of the irrigated area (Table 3) was accompanied by an increase in its water supply. Both of these processes led to an increase in weaning from the river (Table 4, Figure 3). The lack of information on water withdrawal at the end of the 1930s in a number of irrigation areas limited the information content of table 4. However, the information provided in it allows us to appreciate how substantially the withdrawal of runoff from the rivers of the basin has increased.

The Syr Darya River and its basin belong to the areas of ancient irrigation. In 1913, in the upper and middle reaches of the Syr Darya river basin, 1073 thousand hectares were irrigated. The following years, the irrigation area only increased (Table 3). Its water availability has also increased (Rubinova, 1979). These processes led to an increase in weaning flow from the Syr Darya river. The Syr Darya basin is characterized by greater pressure on water resources. Even in the 1930s, losses amounted to more than 60% of the flow. The influx of water into the sea began to stop in the mid-1970s. The use of irrigated agriculture is relatively higher here than in the Amudarya basin: at present it is 85%. At the same time, the share of natural losses decreased from 50% of total losses to 3%. Water supply of the population and industry plays an important role in the Syr Darya basin and accounts for more than 10% of the total losses (Belyaev, 1995).

The largest water consumer is irrigated agriculture. The largest irrigated area is located in the Fergana Valley; it is also significant in the Hungry Steppe and the Tashkent oasis. In the lower reaches of the river, the largest irrigated tracts are Arys-Turkestan and Kyzylorda. Within Kyrgyzstan, smaller areas are irrigated (Chembarisov et al., 2013).

Table 4 – Specific withdrawal from surface water to irrigation zone of the river basin Syrdarya, thousand m^3/ha

Periods	Ferghana Valley	CHAKIR	Hungry Steppe and Dalverzin Steppe	Downstream
1931-1940	11.7		13.9	
1941-1950	14.5		13.2	
1951-1960	15.7	16.1	12.3	38.6
1961-1970	17.3	16.7	13.9	45.1
1971-1980	16.1	16.6	13.5	35.1
1981-1990	17.1	15.1	13.5	35.7
1991-2000	-	16.1	-	35.2
2001-2010	-	16.2	-	-

From 1950 to 2012, the irrigated area in the river basin increased by 2 times and reached 10.14 million hectares. During this period, the area of irrigated land in the region increased by 94%; over the decades, these increases were: 1950-1965. – by 12%; 1965-1975 by 20%; 1975-1985 – by 44% and 1985-1995 – by 25%; this is an overload for ecological systems (Mustafaev and Kozykeeva, 2012). Therefore, environmental degradation of the environment in the Aral Sea Basin is a direct consequence of the intensive expansion of irrigated areas in the river basin.

The dynamics of the expansion of irrigated land from 1950 to 2012 shows that the pace of the introduction of new areas in the region was very high. Every year, from 1.2 to 2.8% of new lands were introduced into economic circulation, and this indicator in Tajikistan and Uzbekistan reached a record level of 3.4 and 3.3% (Mustafaev and Kozykeeva, 2012). In the Syr Darya river basin, between 1976 and 1980, irrigated lands of more than 280 thousand hectares were cultivated, in 1981–1985 and 1986–1990 over 180 thousand hectares.

According to the data of BWO «Syr Darya» and DB CAREWIB, the total water intake in the Syr Darya river basin was approximately 50,000 million m^3 on average in 1980–1990, of which 38,000 million m^3 was for irrigation. This means that more than 70% of the total water intake was taken for irrigation. In the period 1990-2000 this figure was 45,000 million m^3, of which about 32,000 million m^3were taken for irrigation. At present, it is about 41,000 million m^3, of which 31,000 million m^3 for irrigation. This is 75% of the total water intake. A large amount of water intake from the rivers of the Syr Darya basin is passed in Kazakhstan and Uzbekistan. They take 80% of the total water intake. Also, irrigation water intake is very high in these countries.

For the Kyrgyz Republic and the Republic of Kazakhstan, more than 90% of water intake goes to irrigation. For the Republic of Tajikistan, the water intake for irrigation is more than 70%, for the Republic of Uzbekistan, 60% (Figure 3).

As can be seen from Figure 3.4, the development of agricultural lands in the Syr Darya River Basin has a great influence, first of all, on the nature of the use of water resources of the basin. It is also clear that the river flow has decreased due to an increase in irrigation and water intake areas. In dynamics, it is clear that since the 1970s, the area of irrigated land has rapidly increased, reaching its peak in the period 1980-1990. Some of the reduction in irrigated area is due to the fact that land degradation processes in the region and the general economic downturn in agriculture in 1990-2000. Although, after independence, the area of irrigated land in the Central Asian states did not change much (with the exception of Turkmenistan, where the area of irrigated land increased in 1995-1996).

Over the past 20 years, the specific water consumption in the basin has gradually decreased as a result of water withdrawal limits set by intergovernmental organizations (1980 – 18,200 m^3/ha, 1990 – 14,600 m^3/ha, 1995 – 12 200 m3/ha and 1998 – 12,400 m^3/ha)

A number of natural low-water years observed in recent years (2000–2001, 2010–2011), as well as anthropogenic changes in the flow of the Syr Darya River, cause significant damage to the national economy, including the agricultural complex. Due to drought and lack of irrigation water, rural residents also experience great difficulties and losses.

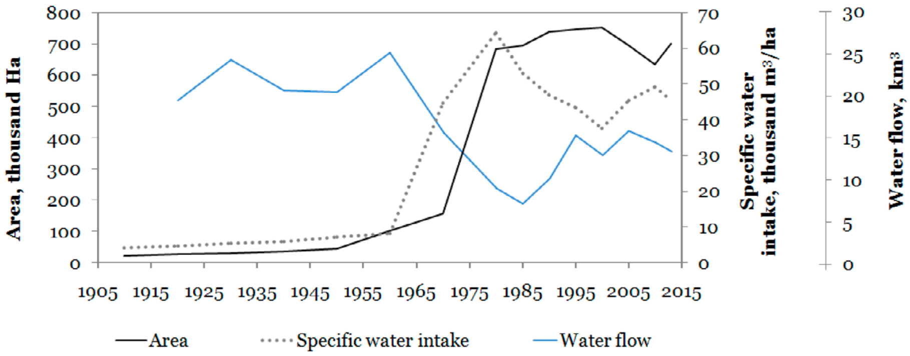

Figure 3 – Dynamics of changes in irrigation areas, river flow and specific water intake in the Syr Darya river basin

Taking into account channel losses and evaporation in watering the delta and natural-ecological systems, about 10 km^3 / year of water is limited to maintain the level of the Aral Sea, which sufficiently maintained the hydro-ecological state of the Aral Sea region. The deterioration of the situation occurred in the period from 1971 to 1985. First, in the region there was a long dry season. Secondly, although the specific water consumption decreased to 35.1 thousand m^3/ha, but with the expansion of irrigated land to 199 thousand hectares, the amount of flow required for irrigation reached 7 km^3/year. In dry years, only irrigated agriculture was maintained, the remaining water users experienced an acute shortage of water resources.

Conclusions

In this chapter, we have analyzed the various types of human activity in the Syr Darya river basin. Considering the change in LCLU in the basin, we can be concluded that the main type of land use in the river basin is grassland, which mostly used for pasture and cropland; more than 80 percent are irrigated. Moreover, during the consider period in the basin the population increasing. Population growth means increased water use, water supply and increased irrigation land to provide the population with food.

In addition, water management construction, such as reservoirs and water withdrawal canals, is considered in the work. Water construction directly affects the river runoff of the basin, thereby changing its hydrological regime. Especially large water construction occurred in the period 1960-1980. At the same time, irrigation area have grown significantly. The growth of irrigation area has led to even greater withdrawal of surface water resources. Currently, the most large irrigation region is located in Uzbekistan. Therefore, more than 90 percent of the water withdrawn here goes for irrigation.

The findings of this study provide useful information to water resource organization, environmentalists and other water resource specialist to the implementation of appropriate strategies for the improvement of water management efforts. Further studies are recommended to monitor other water quality parameters for trends.

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