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NATURAL-GEOGRAPHIC AND HYDROLOGICAL CHARACTERISTICS OF THE SYR DARYA RIVER BASIN

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Abstract: The article provides a generalized natural-geographic and hydrological description of the Syr Darya river basin based on an analysis of classical and contemporary scientific literature. The position of the basin, the structure of its relief, its climatic conditions, the sources of river feeding and the features of the seasonal and long-term runoff regime are considered. Particular attention is paid to the division of the basin into a zone of runoff formation and a zone of runoff dissipation, which, in the author's view, is the key to understanding its water resources. It is shown that discrepancies in the published values of basin area and runoff are largely explained by differences in the boundaries and periods used by different authors. The results may serve as a basis for further hydrological modeling and water management planning.
Keywords: Syr Darya, river basin, Naryn, Kara Darya, runoff regime, snow and glacier feeding, zone of runoff formation, Fergana Valley.

Annotatsiya: Maqolada klassik va zamonaviy ilmiy adabiyotlar tahlili asosida Sirdaryo havzasining umumlashtirilgan tabiiy-geografik va gidrologik tavsifi berilgan. Havzaning joylashuvi, relyef tuzilishi, iqlim sharoitlari, daryoning to‘yinish manbalari hamda yil ichidagi va ko‘p yillik oqim rejimining xususiyatlari ko‘rib chiqilgan. Muallif fikricha havza suv resurslarini tushunishning kaliti bo‘lgan oqim shakllanish va oqim sarflanish zonalariga bo‘linishga alohida e’tibor qaratilgan. Havza maydoni va oqim miqdori bo‘yicha nashr etilgan qiymatlardagi tafovutlar ko‘p jihatdan mualliflar foydalangan chegaralar va davrlarning farqi bilan izohlanishi ko‘rsatilgan. Natijalardan keyingi gidrologik modellashtirish va suv xo‘jaligini rejalashtirishda asos sifatida foydalanish mumkin.
Kalit so‘zlar: Sirdaryo, daryo havzasi, Norin, Qoradaryo, oqim rejimi, qor-muzlik to‘yinishi, oqim shakllanish zonasi, Farg‘ona vodiysi.

Аннотация: В статье на основе анализа классической и современной научной литературы дана обобщённая физико-географическая и гидрологическая характеристика бассейна реки Сырдарьи. Рассмотрены положение бассейна, строение рельефа, климатические условия, источники питания реки и особенности внутригодового и многолетнего режима стока. Особое внимание уделено разделению бассейна на зону формирования и зону рассеяния стока, которое, по мнению автора, является ключом к пониманию его водных ресурсов. Показано, что расхождения в опубликованных значениях

площади бассейна и величины стока во многом объясняются различием границ и периодов, используемых разными авторами. Результаты могут служить основой для дальнейшего гидрологического моделирования и водохозяйственного планирования.

Ключевые слова: Сырдарья, речной бассейн, Нарын, Карадарья, режим стока, снегово-ледниковое питание, зона формирования стока, Ферганская долина.

INTRODUCTION

The Syr Darya is the longest river of Central Asia and one of the two main sources of water in the Aral Sea basin. Its waters irrigate the Fergana Valley, the Hungry Steppe and the lower plains of southern Kazakhstan, drive hydropower plants in Kyrgyzstan and provide drinking water to millions of people in four states. Any discussion of how climate change or human activity affects the water resources of the region therefore needs a clear picture of the basin itself: where its runoff comes from, how it is distributed in time and space, and which natural conditions determine its behavior. Such descriptions do exist in the classical literature, but they are scattered across publications of different periods and are often based on different basin boundaries and different observation series, which leads to noticeable inconsistencies in the figures quoted in modern works. The aim of this article is to provide a generalized natural-geographic and hydrological characterization of the Syr Darya basin through a critical analysis of these sources and to identify the features of the basin that matter most for the assessment of its water resources.

METHODOLOGY AND LITERATURE REVIEW

The study is based on the analysis and comparison of published sources; no field observations, experiments or interviews were carried out, and comparative-geographical analysis, generalization and systematization were used as the principal methods. The foundation of the hydrological description of the basin was laid by V.L. Shults, whose monograph on the rivers of Central Asia proposed a classification of rivers by type of feeding and remains the main reference on the regime of the region's mountain rivers [1]. The fundamental reference series on the surface water resources of the USSR, which devoted a separate issue to the Syr Darya basin, contains systematic data on the hydrographic network, runoff and its distribution for the period of natural or slightly disturbed regime [2]. A comprehensive account of water management in the basin, including the history of its regulation and the role of interstate agreements, is given in the monograph by V.A. Dukhovny and J. de Schutter [3]. The physical geography of Uzbekistan, including the relief and climate of the Uzbek part of the basin, is described by P. Baratov [4]. The glaciers of the Central Asian mountains as a source of river feeding were studied by G.E. Glazyrin [5], while recent changes in Tien Shan glaciation and their hydrological consequences are analyzed by A. Sorg and co-authors [6] and by D. Farinotti and co-authors [7]. The consequences of water use in the basin for the Aral Sea are summarized by P. Micklin [8]. Data on the climate of Uzbekistan and its recent changes are presented in the Third National Communication of the Republic of Uzbekistan under the UN Framework Convention on Climate Change [9], and the state of knowledge about the water cycle of Central Asian headwaters is reviewed by K. Unger-Shayesteh and colleagues [10]. Taken together, these sources allow the classical description of the basin to be checked against the results of recent research.

RESULTS AND DISCUSSION

The Syr Darya is formed by the confluence of the Naryn and the Kara Darya in the eastern part of the Fergana Valley. Measured from this confluence its length is about 2,200 km, and if the Naryn is taken as its source the total length of the river system exceeds 3,000 km. The river crosses the Fergana Valley, leaves it through the narrow passage near Khujand, crosses the Hungry Steppe,

turns to the northwest and, running along the eastern edge of the Kyzylkum desert, reaches the Northern (Small) Aral Sea. The basin therefore extends across Kyrgyzstan, Uzbekistan, Tajikistan and Kazakhstan. Published values of its area vary widely, from roughly 219 thousand to more than 400 thousand square kilometers [3; 8]. In the author's opinion this discrepancy reflects definition rather than error: the smaller figures refer to the area that actually contributes runoff, while the larger ones include desert plains that are hydrologically connected to the river only formally. For hydrological purposes the first approach is the more meaningful one.

The relief of the basin is sharply contrasted. Its eastern and southern parts are occupied by the ranges of the Tien Shan and the Pamir-Alay system, including the Fergana, Chatkal, Kurama, Turkestan and Alay ranges, with summits above 4,000 to 5,000 m, while the western and northern parts are low plains lying 100 to 300 m above sea level [4]. Between them lies the Fergana Valley, an intermountain depression enclosed by mountains on almost all sides. This structure governs the vertical zonation of climate and the sharp contrast between the humid mountain belt, where annual precipitation on windward slopes may reach 800 to 1,000 mm and more, and the arid plains, where it falls to 100 to 200 mm and potential evaporation exceeds precipitation many times over [4; 9]. The climate of the basin as a whole is markedly continental, with hot dry summers and cold winters, and most precipitation falls in the cold half of the year, accumulating in the mountains as snow.

From the hydrological point of view, the defining feature of the basin is its division into a zone of runoff formation and a zone of runoff dissipation. Almost all runoff is formed in the mountains, whereas on the plains the river receives practically no permanent inflow and loses water to evaporation, infiltration and, above all, irrigation withdrawals. According to estimates cited in the literature, roughly three quarters of the natural runoff is formed on the territory of Kyrgyzstan [3]. The mean annual natural runoff of the basin is usually estimated at about 37 km³, although values differ depending on the observation period and the method used to restore natural flow [2; 3].

The rivers of the basin are fed mainly by melting snow and glaciers. In Shults's classification the Naryn and the high mountain tributaries belong to the snow-glacier type, with maximum flow in June and July, while the rivers draining the middle mountains are fed predominantly by snow and peak in April and May [1]. The share of glacier melt in annual runoff is relatively modest, but in the second half of summer, when snow reserves are exhausted, it becomes decisive [5]. This is why the state of glaciers matters for water availability precisely in the season of highest irrigation demand. Recent studies show that Tien Shan glaciers have lost a substantial part of their mass and area since the 1960s [6; 7], and the reviewed literature agrees that this process will gradually alter the seasonal pattern of runoff [10].

The natural regime of the Syr Darya has been fundamentally transformed by regulation. The Toktogul reservoir on the Naryn, with a total capacity of about 19.5 km³, together with the Kairakkum, Chardara, Andijan and Charvak reservoirs and an extensive canal network, has made the river one of the most heavily regulated in the world [3]. After 1991 the Toktogul reservoir shifted from an irrigation-oriented to an energy-oriented regime, increasing winter releases and reducing summer ones, which created a persistent coordination problem between upstream and downstream states [3; 8]. As a result, the observed flow in the middle and lower reaches reflects management decisions as much as natural conditions, and the volume reaching the Aral Sea has shrunk to a fraction of its natural value [8].

CONCLUSION

The analysis supports several conclusions. The Syr Darya basin is a complex natural system in which mountain and plain territories play fundamentally different hydrological roles: the former generate runoff and the latter consume it. The water resources of the basin are formed mainly by

snow and glacier melt in the Tien Shan and Pamir-Alay, which makes them particularly sensitive to changes in temperature. Discrepancies in the published values of basin area and runoff are largely explained by differences in boundaries and reference periods and should be taken into account whenever sources are compared. Finally, the present hydrological regime of the river results from the interaction of natural factors with intensive regulation and water use. These features should underpin any further assessment of the impact of climatic and anthropogenic factors on the water resources of the basin and any attempt to model them with geoinformation technologies.

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